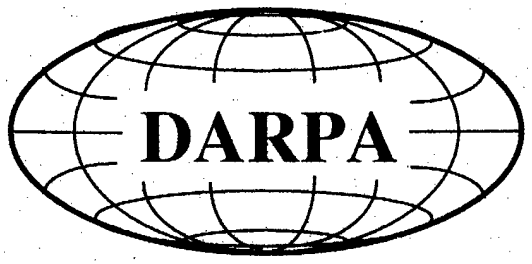
POM 2000 - 2005
DESCRIPTIVE SUMMARIES

May 22, 1998



Defense Advanced Research Projects Agency

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DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Table of Contents

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSEWIDE
PE/PROJECT LEVEL SUMMARY REPORT
($ in millions)

PE	PROJ	TITLE	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
61101E	CCS-02	INFORMATION SCIENCES	16.817	18.900	20.100	19.500	19.700	19.700	20.700	21.700
	ES-01	ELECTRONIC SCIENCES	37.210	28.511	22.910	30.583	30.433	36.183	37.183	38.183
	MS-01	MATERIALS SCIENCES	14.305	17.691	22.390	19.953	21.053	21.053	22.053	23.053
	61101E	**DEFENSE RESEARCH SCIENCES**	**68.332**	**65.102**	**65.400**	**70.036**	**71.186**	**76.936**	**79.936**	**82.936**
62110E	**NGI-01**	**NEXT GENERATION INTERNET**	**40.453**	**40.000**	**40.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
62301E	ST-01	JASONS	1.291	1.200	1.200	1.200	1.200	1.200	1.200	1.200
	ST-11	INTELLIGENT SYSTEMS & SOFTWARE	91.981	81.700	65.499	61.656	51.926	51.591	56.591	50.391
	ST-19	HIGH PERFORMANCE AND GLOBAL SCALE SYSTEMS	157.784	193.314	176.863	183.595	191.727	198.329	200.329	203.329
	ST-22	SOFTWARE ENGINEERING TECHNOLOGY	16.609	17.100	17.600	18.100	18.700	19.300	19.300	19.300
	ST-24	INFORMATION SURVIVABILITY	41.372	54.509	58.640	59.125	78.182	101.128	101.128	101.128
	ST-26	JOINT INFRASTRUCTURE PROTECTION	0.000	69.900	0.000	0.000	0.000	0.000	0.000	0.000
	62301E	**COMPUTING SYS & COMM TECHNOLOGY**	**309.037**	**417.723**	**319.802**	**323.676**	**341.735**	**371.548**	**378.548**	**375.348**
62383E	**BW-01**	**BIOLOGICAL WARFARE DEFENSE**	**60.805**	**88.000**	**92.500**	**98.000**	**101.000**	**105.800**	**106.800**	**107.800**
62702E	TT-03	NAVAL WARFARE TECHNOLOGY	20.783	16.796	11.553	14.172	27.172	27.172	27.172	27.172
	TT-04	ADVANCED LAND SYSTEMS TECHNOLOGY	20.817	35.000	45.750	46.686	55.686	60.886	60.886	60.886
	TT-05	ADVANCED TARGETING TECHNOLOGY	0.000	0.000	0.000	0.000	10.000	38.300	48.300	58.300
	TT-06	ADVANCED TACTICAL TECHNOLOGY	55.091	71.534	57.767	55.728	61.800	68.728	68.728	68.728
	TT-07	AERONAUTICS TECHNOLOGY	20.235	34.000	41.000	59.011	55.000	55.648	55.648	55.648
	TT-10	ADVANCED LOGISTICS TECHNOLOGY	21.214	21.665	10.633	10.000	20.000	20.000	20.000	20.000
	TT-11	JOINT LOGISTICS ACTD	10.191	10.000	10.000	10.000	10.000	0.000	0.000	0.000
	62702E	**TACTICAL TECHNOLOGY**	**148.331**	**188.995**	**176.703**	**195.597**	**239.658**	**270.734**	**280.734**	**290.734**
62708E	**IC-03**	**INTERGRATED COMMAND & CONTROL TECH**	**45.695**	**34.000**	**32.000**	**32.000**	**0.000**	**0.000**	**0.000**	**0.000**
62712E	MPT-01	MATERIALS PROCESSING TECHNOLOGY	122.081	145.381	156.066	196.327	190.280	170.227	175.227	185.227
	MPT-02	MICROELECTRONIC DEVICE TECHNOLOGIES	74.520	87.910	87.522	78.881	69.426	80.413	90.413	100.413
	MPT-06	CRYOGENIC ELECTRONICS	18.404	8.203	11.546	12.000	15.000	16.000	16.000	16.000
	MPT-07	MILITARY MEDICAL/TRAUMA CARE TECHNOLOGY	16.348	2.914	0.000	0.000	0.000	0.000	0.000	0.000
	62712E	**MATERIALS & ELECTRONICS TECHNOLOGY**	**231.353**	**244.408**	**255.134**	**287.208**	**274.706**	**266.640**	**281.640**	**301.640**

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSEWIDE
PE/PROJECT LEVEL SUMMARY REPORT
($ in millions)

PE	PROJ	TITLE	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
63285E	**ASP-01**	**ADVANCED AEROSPACE SYSTEMS**	**0.000**	**0.000**	**13.000**	**19.000**	**23.000**	**5.000**	**5.986**	**9.986**
63739E	MT-03	UNCOOLED INTEGRATED SENSORS	8.669	11.000	3.000	0.000	0.000	0.000	0.000	0.000
	MT-04	ELECTRONIC MODULE TECHNOLOGY	68.268	65.992	61.142	47.395	53.999	81.363	84.925	86.925
	MT-05	TACTICAL INFORMATION SYSTEMS	29.472	36.496	19.640	22.748	21.100	0.000	0.000	0.000
	MT-06	MICROWAVE & ANALOG FRONT END TECHNOLOGY	18.250	4.000	0.000	0.000	0.000	0.000	0.000	0.000
	MT-07	CENTERS OF EXCELLENCE	3.852	4.000	0.000	0.000	0.000	0.000	0.000	0.000
	MT-08	MANUFACTURING TECHNOLOGY APPLICATIONS	29.162	25.200	20.253	0.000	0.000	0.000	0.000	0.000
	MT-10	ADVANCED LITHOGRAPHY	51.078	26.500	28.000	24.000	27.500	24.754	24.754	24.754
	MT-12	MEMS	73.158	71.549	78.979	80.000	79.000	88.300	96.300	93.300
	MT-15	MIXED TECHNOLOGY INTEGRATION	0.000	0.000	36.000	71.205	53.510	50.000	50.000	50.000
	63739E	**ADVANCED ELECTRONICS TECHNOLOGY**	**281.909**	**244.737**	**247.014**	**245.348**	**235.109**	**244.417**	**255.979**	**254.979**
63746E	**MR-01**	**MARITIME TECHNOLOGY**	**36.030**	**15.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
63747E	**EV-01**	**ELECTRIC VEHICLES**	**14.522**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
63760E	CCC-01	COMMAND & CONTROL INFORMATION SYSTEMS	64.125	81.200	109.446	106.034	106.734	105.034	107.034	108.034
	CCC-02	INFORMATION INTEGRATION SYSTEMS	85.885	118.900	115.440	108.544	117.849	117.549	118.549	117.549
	63760E	**COMMAND, CONT'L & COMMUNICATION SYS**	**150.010**	**200.100**	**224.886**	**214.578**	**224.583**	**222.583**	**225.583**	**225.583**
63761E	CST-01	ADVANCED SIMULATION	30.142	26.698	0.000	0.000	0.000	0.000	0.000	0.000
	CST-02	GLOBAL GRID COMMUNICATIONS	41.302	27.916	13.450	0.000	0.000	0.000	0.000	0.000
	CST-03	DEFENSE SIMULATION INTERNET	2.768	1.500	0.000	0.000	0.000	0.000	0.000	0.000
	63761E	**COMMUNICATION & SIMULATION TECH**	**74.212**	**56.114**	**13.450**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
63762E	SGT-01	GUIDANCE TECHNOLOGY	36.668	36.872	16.766	22.731	22.633	35.764	36.764	39.764
	SGT-02	AEROSPACE SURVEILLANCE TECHNOLOGY	19.603	70.500	82.551	72.729	73.517	93.486	80.500	87.500
	SGT-03	AIR DEFENSE INITIATIVE	20.906	33.050	50.210	27.180	32.460	35.000	38.000	38.200
	SGT-04	SENSORS & EXPLOITATION SYSTEMS	90.007	72.732	81.670	91.253	99.476	92.832	92.832	92.832
	63762E	**SENSOR & GUIDANCE TECHNOLOGY**	**167.184**	**213.154**	**231.197**	**213.893**	**228.086**	**257.082**	**248.096**	**258.296**

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
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($ in millions)

PE	PROJ	TITLE	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
63763E	MRN-02	ADVANCED SHIP/SENSOR SYSTEM	19.626	24.788	36.998	43.464	48.396	58.696	60.696	63.696
63764E	LNW-01	RAPID STRIKE FORCE TECHNOLOGY	42.315	52.600	38.000	30.000	50.000	22.000	22.000	22.000
	LNW-02	SMALL UNIT OPERATIONS	38.609	55.890	55.413	59.700	51.500	65.000	65.000	65.000
	63764E	LAND WARFARE TECHNOLOGY	80.924	108.490	93.413	89.700	101.500	87.000	87.000	87.000
63765E	CLP-01	CLASSIFIED DARPA PROGRAMS	129.411	55.500	49.500	36.876	37.000	0.000	0.000	0.000
63800E	JA-01	JOINT STRIKE FIGHTER PROGRAM	23.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63805E	GC-01	DUAL USE APPLICATIONS PROGRAM	120.395	0.000	0.000	0.000	0.000	0.000	0.000	0.000
65114E	BL-01	BLACKLITE	4.532	5.000	5.000	5.000	5.000	5.000	5.000	5.000
65898E	MH-01	MANAGEMENT HEADQUARTERS	35.039	38.611	40.603	42.024	43.541	45.164	46.602	46.602
	AGENCY TOTAL		2,040.819	2,039.722	1,936.600	1,916.400	1,974.500	2,016.600	2,062.600	2,109.600

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSEWIDE
PE/PROJECT LEVEL SUMMARY REPORT
($ in millions)

PE	PROJ	TITLE	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
	BA-01	TOTAL	68.332	65.102	65.400	70.036	71.186	76.936	79.936	82.936
	BA-02	TOTAL	835.674	1,013.126	916.139	936.481	957.099	1,014.722	1,047.722	1,075.522
	BA-03	TOTAL	1,097.242	917.883	909.458	862.859	897.674	874.778	883.340	899.540
	BA-06	TOTAL	39.571	43.611	45.603	47.024	48.541	50.164	51.602	51.602
	AGENCY TOTAL		2,040.819	2,039.722	1,936.600	1,916.400	1,974.500	2,016.600	2,062.600	2,109.600

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 1 Basic Research	R-1 ITEM NOMENCLATURE: Defense Research Sciences, PE 0601101E, R-1 #2

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Defense Research Sciences	**68,332**	**65,102**	**65,400**	**70,036**	**71,186**	**76,936**	**79,936**	**82,936**	**Continuing**	**Continuing**
Information Sciences CCS-02	16,817	18,900	20,100	19,500	19,700	19,700	20,700	21,700	Continuing	Continuing
Electronic Sciences ES-01	37,210	28,511	22,910	30,583	30,433	36,183	37,183	38,183	Continuing	Continuing
Materials Sciences MS-01	14,305	17,691	22,390	19,953	21,053	21,053	22,053	23,053	Continuing	Continuing

(U) **Mission Description**: The Defense Research Sciences Program element is budgeted in the Basic Research Budget Activity because it provides the technical foundation for long-term improvements through the discovery of new phenomena and the exploration of the potential of such phenomena for national security applications. It supports the scientific study and experimentation that is the basis for more advanced knowledge and understanding in information, electronic and materials sciences.

(U) The Information Sciences project supports basic scientific study and experimentation in information sciences technology areas such as Quantum Computing, biological computing, and human-language systems.

(U) The Electronic Sciences project explores and demonstrates electronic and optoelectronic devices, circuits, and processing concepts that will provide: (1) new technical options for meeting the information gathering, transmission and processing required to maintain near-real time knowledge of the enemy, and the ability to communicate decisions based on that knowledge to all forces in near-real time; and (2) a substantial increase in performance and cost reduction of military systems providing these capabilities.

(U) The Materials Sciences project is concerned with the development of: high power density/high energy density mobile and portable power sources; processing and design approaches for nanoscale and/or biomolecular materials and interfaces; medical pathogen countermeasures; materials and measurements for molecular-scale electronics; and advanced thermoelectric materials for cooling and power generation.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide, BA 1 Basic Research	R-1 ITEM NOMENCLATURE: Defense Research Sciences, PE 0601101E

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Information Sciences CCS-02	16,817	18,900	20,100	19,500	19,700	19,700	20,700	21,700	Continuing	Continuing

(U) **Mission Description:** This project supports scientific study and experimentation that is the basis for more advanced knowledge and understanding in information sciences technology areas related to long-term national security requirements such as: computational models, and new mechanisms for performing computation.

(U) In the area of Quantum Computing, the project will identify and probe new classes of computing technologies which may offer spectacular performance/cost/size/weight/power improvements beyond the ultimate limitations of today's semiconductor-based computing. Quantum logic, based on subatomic scale physical phenomena, could enable a tremendous leap in computational capacity. However, a number of significant hurdles, including the development of sequencing mechanisms, large scale storage, input/output channels and quantum-enabled approaches to algorithms and error correction must be overcome.

(U) In the area of biological computing, the project will support the scientific study and experimentation that is at the interface of information technology and biological technology, with emphasis on: biological software, computation based on biological material, physical interfaces between electronics and biology, and interactive biology. It will also apply information technology to accelerate the analysis and synthesis of biological processes. The seamless integration of information technology and biological processes will provide spectacular computational capabilities and the ability to exert computational control over biological and chemical processes.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Investigated computational models suitable for implementation using Quantum computing techniques. ($5.7M)
- Developed architecture for low-power configurable computational elements. ($1.3M)
- Prototyped robust spoken and text language technologies with emphasis on affordable grammars and understanding. ($7.9M)
- Evaluated quality of service specifications; demonstrated real-time adaptive control and resource management; released version of defense-critical software based on scalable library technology. ($1.9M)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 1 Basic Research	R-1 ITEM NOMENCLATURE: Defense Research Sciences, PE 0601101E, Project CCS-02

(U) FY 1999 Program:

- Demonstrate and validate computing models, with emphasis on: DNA-based logic operations; cell-based computation and novel communication pathways; and the scalability of these techniques in defense applications. ($12.2M)
- Investigate novel control mechanisms for self-organizing and autonomous systems. ($2.0M)
- Demonstrate human-computer interaction for crisis planning and automatic transcription of conversational speech. ($3.0M)
- Validate low-power configurable architecture; develop supporting software; and demonstrate automated mapping of 500K elements. ($1.7M)

(U) FY 2000 Program:

- Biological Computing. ($14.7M)
  - Demonstrate feasibility of alternative approaches to DNA-based computation.
  - Evaluate alternative approaches to DNA-based computing and identify most promising research opportunities for enhancement and acceleration.
  - Design robotic control mechanisms for sequencing of DNA-based computations.
  - Investigate novel approaches to real-time biological instrumentation in support of interactive biology.
- Quantum Computing. ($5.4M)
  - Develop new algorithms for quantum-enabled computation.
  - Design sequencing and input/output mechanisms for quantum computing.

(U) FY 2001 Program:

- Biological Computing. ($13.5M)
  - Prototype demonstration of robot control sequencing of DNA-based computations.
  - Demonstrate real-time multi-sensor imaging of cell processes in support of interactive biology.
  - Investigate high speed synthesis of DNA segments of at least 100 base pairs.
- Quantum Computing. ($6.0M)
  - Simulate new algorithms for quantum-enabled computation and evaluate potential speed-up over conventional methods.
  - Prototype demonstration of sequencing and input/output mechanisms enabling quantum computing.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide, BA 1 Basic Research	R-1 ITEM NOMENCLATURE: Defense Research Sciences, PE 0601101E, Project CCS-02

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	16.8	18.9	20.1	19.5
Appropriated	16.8	N/A	N/A	N/A
Current Budget	16.8	18.9	20.1	19.5

(U) **Change Summary Explanation**: N/A

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE May 1998		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 1 Basic Research					R-1 ITEM NOMENCLATURE Defense Research Sciences, PE 0601101E					
COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Electronic Sciences ES-01	37,210	28,511	22,910	30,583	30,433	36,183	37,183	38,183	Continuing	Continuing

(U) **Mission Description:** This project seeks to continue the phenomenal progress in microelectronics innovation that has characterized the last decades by exploring and demonstrating electronic and optoelectronic devices, circuits and processing concepts that will: 1) provide new technical options for meeting the information gathering, transmission and processing required to maintain near real-time knowledge of the enemy, and the ability to communicate decisions based on that knowledge to all forces in near real-time; and 2) provide new means for achieving substantial increases in performance and cost reduction of military systems providing these capabilities. Research areas include new electronic and optoelectronic device and circuit concepts, operation of devices at higher frequency and lower power, extension of diode laser operation to new wavelength ranges relevant to military missions, development of uncooled and novel infrared detector materials for night vision and other sensor applications, development of innovative optical and electronic technologies for interconnecting modules in high performance systems, research to realize field portable electronics with reduced power requirements, and research addressing affordability and reliability. Additionally, electronically controlled microinstruments offer the possibility of nm-scale probing, sensing and manipulation for ultra-high density information storage `on-a-chip', for nm-scale patterning, and for molecular level analysis and synthesis. These Microinstruments for nm-scale mechanical, electrical and fluidic analysis offer new approaches to integration, testing, controlling, manipulating and manufacturing nm-scale structures, molecules and devices.

(U) Program Accomplishments and Plans:

(U) FY 1998 Accomplishments:

- Optoelectronics - Demonstrated feasibility of using Gallium Nitride detectors as a UV solar-blind detector for missile threat warning and demonstrated UV/blue lasers operating continuous wave for high density memory and chemical/biological detection. ($9.5M)
- Infrared Detector Materials - Determined process for low temperature deposition of thin film uncooled materials. ($2.7M)
- Ultra-Electronics - Demonstrated feasibility of combining a resonant tunneling device (RTD) with conventional devices, silicon based quantum metal oxide semiconductor (MOS) technology, and simple quantum cellular automatic logic circuits using silicon and silicon germanium structures. ($10.3M)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences, PE 0601101E, Project ES-01

- Ultra-Photonics - Demonstrated practical means for implementing high speed optical buffer memories and signal address recognition based on coherent all-optical (photon-echo) technology. Demonstrated the utility of low cost silicon electronic devices doped with optically active elements (such as Erbium) for applications that were the exclusive domain of more expensive compound semiconductor devices or glassy materials. ($9.2M)
- Low Power Electronics - Completed low-power electronics programs in the areas of circuit architecture and power management techniques. Demonstrated 256 x 256 pixel image sensor with on-chip 10-bit Analog-Digital Converter. ($5.5M)

(U) FY 1999 Program:

- Infrared Detector Materials - Establish feasibility of new uncooled detector structures, including micromachined arrays, thin film ferroelectrics and bolometric materials. ($3.0M)
- Ultra Electronics - Demonstrate programmable matched filter operating at gigahertz speed with substantially less power than silicon complimentary metal oxide semiconductor (Si CMOS), completely integrated molecular beam epitaxy (MBE) growth system which realizes closed-loop control of atomic layer growth and quantum device structures. ($4.9M)
- Ultra-Photonics - Identify the device properties limiting performance of vertical cavity lasers and demonstrate methods for controlling their output beam quality. ($7.7M)
- Integrate promising new elements of ultra-electronics, high power electronics, non-volatile memory and Electro-Magnetic Interference (EMI) electronics. Address, evaluate, and apply current EMI thrusts in smaller, lighter, more mobile information systems and highest performance components and systems. ($9.7M)
- Initiate mechanical electronics development resulting in very high efficiency DC-DC converters. ($1.0M)
- Terahertz Technology - Explore technologies for a region of the electromagnetic spectrum (300Ghz to 10Thz, 1mm to 30 micrometer) which has previously been difficult to access using conventional technologies, in order to exploit opportunities in environmental sensing, upper-atmosphere imagery, and covert satellite communications. ($2.2M)

(U) FY 2000 Program:

- Mechanical Electronics - Demonstrate the properties for mechanical switches which includes device speed and current density scale and size, hysteretic behavior for non-volatile memory applications, and reduce the threshold switching voltage to below 10V. ($2.0M)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences, PE 0601101E, Project ES-01

- Terahertz Technology - Continue to exploit the terahertz region of the electromagnetic spectrum by investigating the best semiconductor approaches to sources and detectors, identifying mission critical operation, and feasibility to integrating these components to form a range of compact subsystems for applications in space based communications, remote sensing, collision avoidance radar, and covert communications. ($3.6M)
- Microinstruments - Demonstrate an integrated and mechanically positioned, nm-scale electrical probe array `on-a-chip' and demonstrate the recording of a 1GHz electrical signal on a 200nm$^2$ area. Demonstrate fluidic deposition and probing on a 20nm x 20nm area. Demonstrate an integrated microinstrument `on-a-chip' that reads an array of 1 billion, 5nm bits. Demonstrate the integrated robotic mechanisms `on-a-chip' for electromagnetic, electromechanical and microfluidic positioning, manipulation and transportation of nm-scale and micrometer-scale objects. Demonstrate molecular level synthesis of biochemical probes. ($17.3M)

(U) FY 2001 Program:

- Terahertz Technology - Demonstrate for the terahertz spectral region the best semiconductor quantum well approaches to sources, demonstrate semiconductor quantum well detectors, and identify system requirements to achieve space communications, upper-atmosphere imagery, and close-operations covert communications. ($3.8M)
- Microinstruments - Demonstrate a patterning microinstrument that writes a pattern of array of 50nm minimum - feature-size (MFS) bits or pixels at a rate of 6cm^2 sec over an area of 1cm^2. Demonstrate fluidic patterning of pixels 20nm x 20nm over a 1mm x 1mm area using a microinstrument `on-a-chip'. Demonstrate an array of 10,000 probes for imaging 10nm defects, electrical pads or bits on an integrated circuit. Demonstrate non-destructive controlled manipulation of cells. ($26.8M)

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	37.2	28.5	25.7	30.6
Appropriated	37.2	N/A	N/A	N/A
Current Budget	37.2	28.5	22.9	30.6

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences, PE 0601101E, Project ES-01

(U) **Change Summary Explanation**:

FY 2000 Decrease reflects completion of the 6.1 portions of the Gallium Nitride and Low Power Electronics programs.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 1 Basic Research	R-1 ITEM NOMENCLATURE: Defense Research Sciences, PE 0601101E

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Materials Sciences MS-01	14,305	17,691	22,390	19,953	21,053	21,053	22,053	23,053	Continuing	Continuing

(U) **Mission Description**: This project is concerned with fundamental research leading to the development of: high power density/high energy density mobile and portable power sources; advanced thermoelectric materials for cooling and power generation; processing and design approaches for nanoscale and/or biomolecular materials and interfaces; materials and measurements for molecular-scale electronics; and medical pathogen countermeasures.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Electrochemistry. ($9.0M)
  - Constructed and tested a logistics fueled fuel cell power plant for mobile electric power applications.
  - Began component and system study/demonstration of a direct oxidation fuel cell for replacement of military standard batteries.
  - Explored alternative sources of energy for portable power applications.
  - Developed and demonstrated thermoelectric and thermophotovoltaic materials with significantly improved performance.
- Nanoscale/Biomolecular Materials. ($1.0M)
  - Exploited recent advances in materials design and processing to demonstrate nanostructural control of materials properties with an emphasis on emulating the complex microstructure and scale of biological materials.
- Pathogen Countermeasures. ($2.5M)
  - Determined one or more mechanisms a stem cell could use to link detection of a pathogen to the production by the cell of vaccines and/or therapeutics.
- Thermoelectric Materials. ($1.8M)
  - Demonstrated materials with a factor of two increase in thermoelectric figure of merit.

(U) FY 1999 Program:

- Portable Power. ($6.5M)
  - Optimize catalysts, polymeric membranes, and separator plates for high energy density fuel cell operation.
  - Brassboard testing of compact, high performance energy sources for portable power applications.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences, PE 0601101E, Project MS-01

- Demonstrate novel thermoelectric and thermophotovoltaic power generation devices based on advanced materials.

• Nanoscale/Biomolecular Materials. ($4.5M)
- Demonstrate the applicability of nanostructural and/or biomolecular materials in Defense applications such as armor, high strength fibers, or coatings.
- Develop single molecules that exhibit electronic functions.
- Measure the intrinsic electronic material properties of selected molecules.

• Pathogen Countermeasures. ($4.2M)
- Determine mechanism of disease-causing (virulence) factors in pathogens of concern to DoD.

• Thermoelectric Materials. ($2.5M)
- Develop thin film cooler utilizing quantum well structures.

(U) FY 2000 Program:

• Portable Power. ($5.0M)
- Demonstrate in the laboratory integrated portable power systems that operate on logistics fuel.
- Demonstrate applicability of portable power systems for individual soldier applications.

• Nanoscale/Biomolecular Materials. ($4.0M)
- Explore capabilities of quasicrystals, carbon nanotubes and other nanostructured materials for enhancing structural and functional performance of defense systems.

• Pathogen Countermeasures. ($3.4M)
- Develop novel initiatives to disrupt disease-causing (virulence) factors in pathogens of concern to the DoD.

• Molecular Electronics. ($10.0M)
- Demonstrate that two interconnected molecules show the anticipated functionality.
- Demonstrate the ability to reversibly and repeatably transfer information from molecule to molecule.
- Demonstrate that molecular materials can perform a storage function that can be driven from one state to the other by an outside signal.

(U) FY 2001 Program:

• Nanoscale/Biomolecular Materials. ($8.3M)
- Demonstrate enhanced performance from materials incorporating nanostructured components.
- Demonstrate the use of quantum chemistry for the theoretical design of new materials and structures.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 1 Basic Research	R-1 ITEM NOMENCLATURE: Defense Research Sciences, PE 0601101E, Project MS-01

- Molecular Electronics. ($11.7M)
  - Demonstrate that molecules can self-assemble into functional, regular, three-dimensional patterns forming a molecular memory.
  - Demonstrate assembly architectures that enable interconnected molecules to function even though some of the molecular components are defective.

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	14.3	17.7	19.6	20.0
Appropriated	13.3	N/A	N/A	N/A
Current Budget	14.3	17.7	22.4	20.0

(U) **Change Summary Explanation**:

FY 1998 Increase reflects expansion of efforts under the pathogen countermeasures program.
FY 2000 Increase reflects expansion of efforts in Molecular Electronics.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Next Generation Internet, PE 0602110E, R-1 #7

COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Next Generation Internet NGI-01	40,453	40,000	40,000	0	0	0	0	0	0	N/A

(U) **Mission Description:** The Next Generation Internet (NGI) initiative has three goals: (1) promote experimentation with the next generation of networking technologies; (2) connect universities and national laboratories with high speed networks that are 100 - 1000 times faster than today's Internet; and (3) demonstrate revolutionary applications that meet important national goals and missions. The principal agencies involved in this initiative are DARPA, NSF, NIST, NIH and NASA. These agencies will share in funding this research and development effort. The DARPA activity will be aimed at part of the first two goals. DARPA will demonstrate end-to-end network connectivity at 1+ gigabits-per-second for 10 or more NGI sites. The network technologies to be addressed include multi-gigabit broadband networks, guaranteed quality of service mechanisms, and integrated network management. These technologies will be demonstrated in an NGI developed testbed environment.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Designed and initiated implementation of the NGI testbed. ($5.0M)
- Created ultra high bandwidth Wavelength Division Multiplexed (WDM) connections for Next Generation Internet (NGI) testbed (Supernet). ($15.0M)
- Developed NGI quality of service architecture and implemented initial operating system services. ($15.0M)
- Defined 10 gigabit-per-second optical switching transmission protocols and network and resource management strategy. ($3.5M)
- Executed Congressionally mandated adjunct to the NGI program. ($2.0M)

(U) FY 1999 Program:

- Implement 10 gigabit-per-second, multi-wave optically switched WDM technology in NGI testbed. ($5.0M)
- Implement an alpha-level prototype high speed optical multiplexor and develop specification of protocol structure. ($15.0M)
- Expand testbed to DoD supported laboratories and to 10 gigabit-per-second links. ($5.0M)
- Implement prototype network management system. ($10.0M)
- Define application program interfaces for information management and collaborative applications. ($5.0M)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 2 Applied Research	R-1 ITEM NOMENCLATURE: Next Generation Internet, PE 0602110E, Project NGI-01

(U) FY 2000 Program:

- Implement prototype of packet switching fabric compatible with 100 Gb/s optical network. ($6.0M)
- Implement streamlined Internet over Wavelength Division Multiplexed (WDM) protocol structure, eliminating two layers of existing telecommunications infrastructure. ($8.0M)
- Develop network planning and simulation technology to meet requirements for NGI scale networks. ($7.5M)
- Demonstrate real-time (100 msec response) monitoring and control of network resources at all levels. ($6.5M)
- Complete interconnection of Supernet testbed components and software with 2.5 gigabit-per-second access architecture, up to 10 gigabit-per-second backbone, and 100 Gb/s distributed switching capacity. ($12.0M)

(U) FY 2001 Program: N/A

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	40.5	40.0	40.0	0
Appropriated	40.5	N/A	N/A	N/A
Current Budget	40.5	40.0	40.0	0

(U) **Change Summary Explanation**: N/A

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 2 Applied Research	R-1 ITEM NOMENCLATURE: Computing Systems and Communications Technology, PE 0602301E, R-1 #12

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Computing Systems and Communications Technology	**309,037**	**417,723**	**319,802**	**323,676**	**341,735**	**371,548**	**378,548**	**375,348**	**Continuing**	**Continuing**
JASON ST-01	1,291	1,200	1,200	1,200	1,200	1,200	1,200	1,200	Continuing	Continuing
Intelligent Systems & Software ST-11	91,981	81,700	65,499	61,656	51,926	51,591	56,591	50,391	Continuing	Continuing
High Performance and Global Scale Systems ST-19	157,784	193,314	176,863	183,595	191,727	198,329	200,329	203,329	Continuing	Continuing
Software Engineering Technology ST-22	16,609	17,100	17,600	18,100	18,700	19,300	19,300	19,300	Continuing	Continuing
Information Survivability ST-24	41,372	54,509	58,640	59,125	78,182	101,128	101,128	101,128	Continuing	Continuing
Joint Infrastructure Protection ST-26	0	69,900	0	0	0	0	0	0	0	N/A

(U) **Mission Description**: This program element is budgeted in the Applied Research Budget Activity because it funds projects directed toward the application of advanced, innovative computing systems and communications technologies.

(U) The High Performance and Global Scale Systems project is developing technologies that will lead to successive generations of more secure, higher performance, and more cost-effective microsystems, associated software defense technologies, advanced mobile information technology, and prototype experimental applications that are critical to operations and federal needs.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology, PE 0602301E

(U) The efforts funded in the Intelligent Systems and Software project focus on the development of new information processing technology concepts that lead to fundamentally new software and intelligent system capabilities. Emphasis areas include sensors, situation presentation, and situational analyses.

(U) The Information Survivability project develops the technology base underlying the solutions to protecting DoD's mission-critical information systems against attack upon or through the supporting infrastructure. These technologies lead to generations of stronger protection, higher performance, and more cost-effective security solutions scalable to several thousand sites and to high-performance computing technologies.

(U) The Joint Infrastructure Protection project examines national cyber defense threats to, and vulnerabilities of, critical infrastructures in the United States through research in the areas of information assurance and "other areas" of infrastructure protection such as intrusion monitoring and detection systems, information collection technologies, and data reduction and analysis tools.

(U) The Software Engineering Technology project supports the Software Engineering Institute (SEI) that works to transition state-of-the-art technology, and best practices to improve the acquisition, engineering, fielding, and evolution of software-intensive DoD systems.

(U) The JASON Group supports studies for the national security community.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 1998	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research				R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology, PE 0602301E						
COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
JASON ST-01	1,291	1,200	1,200	1,200	1,200	1,200	1,200	1,200	Continuing	Continuing

(U) **Mission Description:** This project supports the JASONs, an independent group of distinguished scientists and technical researchers that provides analysis of critical National Security issues. JASON membership is carefully balanced to provide a wide spectrum of scientific expertise and technical analysis in theoretical and experimental physics, materials, information sciences, and other allied disciplines. The JASON process ensures senior government leaders have the full range of U.S. academic expertise available on issues critical to National Security involving classified and unclassified information.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Continued studies in: Counter proliferation of chemical and biological weapons; advanced sensors to support small unit operations; high bandwidth urban communications; characterization of underground facilities; novel energetic materials; small scale propulsion; and land mine detection.

(U) FY 1999 Program:

- Continue studies of interest to DoD in multiple disciplines such as: Counter proliferation of chemical and biological weapons; advanced sensor technologies; advanced computing; land mine detection; battlefield information systems; battlefield planning and control; small unit operations; military communications; and novel materials.

(U) FY 2000 Program:

- Continue studies of interest to DoD in multiple disciplines such as: Counter proliferation of chemical and biological weapons; space based radar; small payload space launch systems; advanced computing; multi-layered infrastructure defense; advanced sensor technologies including increased radar noise floor and deep buried target characterization; dispersed land forces technology; battlefield information systems and military communications; ultra low power electronics; fiber lasers; and self monitoring materials.

(U) FY 2001 Program:

- Continue studies of interest to DoD.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE
	May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology, PE 0602301E, Project ST-01

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	1.2	1.2	1.2	1.2
Appropriated	1.2	N/A	N/A	N/A
Current Budget	1.3	1.2	1.2	1.2

(U) **Change Summary Explanation**:

FY 1998 · Increase reflected minor program repricing.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 2 Applied Research	R-1 ITEM NOMENCLATURE: Computing Systems and Communications Technology, PE 0602301E

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Intelligent Systems and Software ST-11	91,981	81,700	65,499	61,656	51,926	51,591	56,591	50,391	Continuing	Continuing

(U) **Mission Description:** This project develops new information processing technology concepts that lead to fundamentally new software and intelligent systems capabilities. This will enable advanced information systems to more effectively accomplish decision-making tasks in stressful, time sensitive situations and create efficient software intensive defense systems.

(U) Major areas of technical emphasis are: (a) software composition technology including languages, algorithms, components, object brokers and repositories, software design tools, and advanced software engineering environments; (b) active sensors and control strategies that leverage software-based intelligent processing to: acquire sensory information, including advanced airborne video data, and prepare it for higher order processing by situation awareness and analysis tools; and to provide sophisticated feedback and control of subsystems and collections thereof; (c) situation analysis and presentation tools that provide for: the intelligent integration of information from heterogeneous sources; interactive problem solving, planning, scheduling and decision analysis; and the integration and application of emerging language understanding to address both C4I and Intelligence community needs.

(U) As this program matures, it will have a reduced emphasis on software composition, i.e., the methodology and tools used to compose intelligent software. Beginning in FY 2000, there will be an increased emphasis on the development of intelligent applications that leverage the composition tools developed in the earlier phase of the project. Specific application domains of interest are situation analysis, situation presentation, and the processing of sensor-derived information.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Software Composition. ($32.6M)
  - Integrated selected Rapid Design Exploration and Optimization (RaDEO) designed computation tools that demonstrate robust multi-disciplinary design. Demonstrated a 5X reduction in early design trade-off time by combining qualitative & quantitative models.
  - Released design of Formal Language for Expressing Assumptions (FLEA).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology, PE 0602301E, Project ST-11

- Released Version 2 of core architectural description interchange language (ACME) and demonstrated use of ACME to represent multiple domain-specific software models.
- Released real-time dynamic language system for use by Integrated Feasibility Demonstration teams.
- Completed Computer Aided Education and Training Instruction (CAETI) effort to enhance training environments.
- Executed Congressionally mandated Reuse Technology Adoption Program (RTAP).

• Active Sensors. ($22.2M)
- Supported software initiatives at the National Applied Software Engineering Center (NASEC); Johnstown, PA.
- Developed, demonstrated, and evaluated image understanding technologies for image exploitation, automatic population of geospatial database, video surveillance and monitoring, and automatic target recognition to enhance battlefield awareness.
- Developed concept of operations for Airborne Video Surveillance (AVS) system in cooperation with government video surveillance users. Developed AVS detailed system design and multi-year technology build/evaluate plan. Collected ground truthed data of events and moving targets at the Fort A.P. Hill experimental site and used this data for late FY 1998 laboratory demonstrations of precision video registration (PVR), activity monitoring (AM), and moving target surveillance (MTS) technology.

• Situation Analysis. ($37.2M)
- Developed initial prototypes for multi-language text extraction and audio transcription where performance is baselined against that of human operators.
- Continued development of modular Human Language Technologies to support easy, low-cost, rapid technology transfer and application development for Document Understanding, Machine Translation, and Speech Understanding.
- Integrated human-in-the-loop, automated planning, and decision aids techniques for managing military command and control processes in quickly-changing operational settings; demonstrated capabilities to generate, assess, and select among multiple alternative plans in time currently required to generate one plan.
- Used unified ontologies in tools for focused knowledge acquisition; extended learning methods; and added new high-performance, problem-solving methods to the High Performance Knowledge Base library for battlefield awareness, crisis management, and military command and control.
- Developed, in the Intelligent Integration of Information area, tools and techniques to enable the rapid construction of information fusion, aggregation, and summarization software to filter, access, and integrate information from 100s of disparate, heterogenous, distributed data sources.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology, PE 0602301E, Project ST-11

(U) FY 1999 Program:

- Software Composition. ($25.7M)
  - Conduct Instrumented Feasibility Demonstration (IFDs) of evolutionary design technologies; IFD participants include USTRANSCOM, Joint STARS, and B2 software maintenance.
  - Investigate active approaches to software composition, with emphasis on: aspect-oriented programming; on-the-fly component generation & interconnection; and module self-evaluation and configuration.
  - Demonstrate a 2X reduction in detailed design by integrating Design Web and Computational Tools made for multi-disciplinary optimization.
  - Demonstrate web-based toolkit of representation, analysis and generation tools.
- Active Sensors. ($27.5M)
  - Integrate most successful new image understanding and automatic target recognition technologies into feasibility demonstrations for video image exploitation, synthetic environments, and video surveillance; demonstrate & evaluate impact of embedded image understanding technologies on battlefield awareness.
  - Evaluate software-based control mechanisms & their interaction across subsystem boundaries; explore novel approaches to predicting and regulating the collective behavior of mobile software entities.
  - Integrate, demonstrate and evaluate laboratory and airborne systems in a simulated cantonment area monitoring scenario, with these technology goals: Activity Monitoring - Detect soldier incursion and removal of restricted vehicles from a small area or point; Moving Target Surveillance - maintain track on the removed vehicles, with reliable target re-acquisition as the sensor is multiplexed and tracks are occluded by trees; Precision Video Registration - geolocate moving and stationary vehicles in 80% of the video sequences within 5-10 meters of ground truth.
- Situation Analysis. ($28.5M)
  - Develop language comprehension technology to provide extraction of content and production of summary information focused on information access, manipulation and creation tasks in order to demonstrate improved readiness for military planning and situation awareness.
  - Develop and demonstrate fully automatic algorithms to determine the structure of radio and TV news broadcasts in several languages allowing military planners and intelligence analysts to detect and track emerging topics.
  - Develop and demonstrate a large, integrated situation assessment knowledge base through reuse of knowledge base components from heterogeneous sources.
  - Demonstrate the utility of man-machine planning and execution control against an aggressive adversary in a realistic simulation of an operational environment.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 2 Applied Research	R-1 ITEM NOMENCLATURE: Computing Systems and Communications Technology, PE 0602301E, Project ST-11

- Demonstrate and transition Intelligent Integration of Information tools and techniques to enable the rapid construction of large scale information associates to filter, access, and integrate information from 100s of disparate, heterogenous data sources.

(U) FY 2000 Program:

- Active Sensors. ($12.4M)
  - Develop fully automated video sentries detecting and tracking a skilled infantry squad attempting ingress to a built up site from wooded, grassy, and open terrain over a 24 hour period using an array of cooperating visual and thermal sensors.
- Situation Analysis. ($33.1M)
  - Demonstrate statistically-based semantic analysis capabilities across four repositories, at least one of which supports access controls.
  - Generate semantic threads (event-based relationships) within a single document by inference among named entities (people, places, things).
  - Define ontologies, knowledge bases, and reasoning methods for an initial prototype of a large scale (500K+ axiom) battlespace knowledge-base that represents and reasons about transnational threats including assessments of threat activity and predictions of future events.
  - Demonstrate translingual document clustering for representative European and Asian languages, including English, French, Spanish, Russian, Arabic, Japanese, Chinese, and Korean.
- Situation Presentation. ($20.0M)
  - Specify network-based service architecture/API's for key components, and engineering integration of dialogue architecture to support metrics-based evaluation; Demonstrate usability of dialogue interaction with confirming sub-dialogue to reduce task completion time by 80% for a travel reservation task.

(U) FY 2001 Program:

- Active Sensors. ($14.0M)
  - Demonstrate real-time detection of anomalous behavior in streets and indoor scenes by a cooperating sensor array to be followed by tracking targeted subjects with high resolution sensors for automated comparison with a catalog of known subjects.
- Situation Analysis. ($29.1M)
  - Deploy scalable prototype analysis environment in Defense application with cross-repository information analysis functionality (semantic retrieval, indexing, value-filtering, user-defined alerting, categorizing, and interoperability).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology, PE 0602301E, Project ST-11

- Demonstrate initial (75K axiom) transnational threat knowledge base describing the organization and behavior of threat entities and consisting of general purpose and domain specific knowledge acquired through reuse of existing ontologies, acquisition of knowledge from domain experts, extraction of knowledge from the web, text and other sources and discovery of knowledge from transnational threat data bases.
- Demonstrate translingual query formulation with interdomain vocabulary expansion; recognize, extract, translate, and correlate named entities from unstructured documents in multiple languages.

• Situation Presentation. ($18.6M)

- Demonstrate and evaluate dialogue performance for "Project Marine" with a focus on improved projection of power.
- Demonstrate capability of dialogue-based system on a travel reservation task: complete a complex travel task requiring negotiation twice as fast with automated service support as with the best human assistance.

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	92.0	81.7	92.0	117.7
Appropriated	98.6	N/A	N/A	N/A
Current Budget	92.0	81.7	65.5	61.7

(U) **Change Summary Explanation**:

FY 1998 Decrease reflects accelerated completion of the Human Computer Interaction effort stand-alone program and integration of the related technologies into other intelligent systems programs.

FY 2000-01 Reductions reflect DARPA program restructuring and reprioritization.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE May 1998		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research				R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology, PE 0602301E						
COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
High Performance and Global Scale Systems ST-19	157,784	193,314	176,863	183,595	191,727	198,329	200,329	203,329	Continuing	Continuing

(U) **Mission Description:** This project develops the computing, networking, and associated software technology base underlying the solutions to computational and information-intensive applications for future defense and federal needs. These technologies will lead to successive generations of more secure, higher performance, and more cost-effective microsystems, associated software technologies, advanced mobile information technology and prototype experimental applications critical to defense operations. The project is comprised of the following components:

- The Global Mobile Information Systems effort will enable mobile users to access and utilize the full range of services available in the Defense Information Infrastructure. To achieve this goal, it will develop nomadic technologies and techniques at the applications, networking, and wireless link/node levels.
- The Systems Environments component develops scalable software which is tailored toward easing the use of systems by application programmers. This includes run-time services, resource allocation, and experimental applications.
- The Networking component develops active networking technologies and associated network management capabilities to support deeply networked systems. Research is coordinated with network technology and Service deployments made by DoD, NASA, and other federal agencies.
- The Data Intensive Systems and Software component develops software and hardware technologies for data-starved applications. This component will develop a new approach to computer memory organization that will eliminate severe bottlenecks in present designs.
- The Embeddable Microsystems component is pioneering the critical technologies that will enable the widespread penetration of information-based microsystems. Microsystems are the critical bridge that leverage other DARPA technology in low-power processes, advanced packaging, materials, electronic componentry, networking and interfaces to develop the architecture and building blocks of the most advanced tactical devices and systems.
- Defense Technology Integration combines state-of-the-art computing and information technologies to enable automated and comprehensive situation analysis. This includes projects which accelerate technology transition of advanced research to intelligence, command and control, and other major DARPA and DoD programs. Technologies addressed include: information management, integration of federated repositories, multimedia collaboration and visualization, and new approaches to the composition of large scale software-based systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE High Performance and Global Scale Systems, PE 0602301E, Project ST-19

(U) Each of the above components of this program will integrate capabilities developed under the Information Survivability initiative (Project ST-24) to satisfy defense requirements for secure systems.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Global Mobile Information Systems. ($14.9M)
  - Demonstrated middleware services for adapting applications to changing infrastructure resources.
  - Developed advanced algorithms and components for waveform processing at untethered nodes.
  - Developed software modules for reconfigurable radios.
  - Conducted integrated technology demonstrations.
- Systems Environments. ($14.7M)
  - Demonstrated experimental versions of new iterative solvers for radar cross-section modeling; languages and runtime services supporting parallel applications such as Advanced Distributed Simulation; and HPC++ languages and runtime services supporting both task and data parallelism.
- Networking. ($21.4M)
  - Active Networks.
    - * Implemented prototypes of Enhanced Networking Services utilizing composable modules.
    - * Completed prototype implementation of node execution environment; of fast compiler for SmartPacket Methods; and of basic management functions.
    - * Initiated operation of wide area Active Network on prototype platforms.
- Scalable Systems and Software. ($40.0M)
  - Scalable Computing.
    - * Demonstrated highly efficient, parallel nodes; auto-parallelization of file input/output (I/O) for scalable systems; first node-level performance of ultra-low-power systems; and distributed, shared-memory support for a commodity processor.
  - Ultrascale Computing.
    - * Assessed quantum-to-Si hardware and software interface; and language for expressing amorphous algorithmic computations.
    - * Demonstrated 256-component addressed array of molecular computational mechanisms; and evaluated surface patterning mechanisms for culturing neural components on silicon.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE High Performance and Global Scale Systems, PE 0602301E, Project ST-19

- QUORUM/Scalable Software.
  - * Developed quality-of-service negotiation protocols; and adaptive resource discovery protocols.
  - * Demonstrated fault-tolerant allocation of 100K-entity synthetic forces simulation on 1,300 nodes spanning 13 machines at 9 sites.

• Microsystems. ($28.5M)
- Microsystems Design.
  - * Demonstrated formal methods for microprocessor verification.
  - * Demonstrated integrated environment for design of advanced microcomponents.
- Adaptive Computing Architectures.
  - * Developed novel subsystem designs that use configurable component technology.
  - * Demonstrated adaptive template matching concept through software prototype capable of automated runtime remapping.

• Defense Technology Integration and Infrastructure. ($23.3M)
- Information Management.
  - * Developed algorithms to effectively search collections of documents for words used only in restricted senses; and design query and preference languages incorporating similarity and value filtering.
  - * Investigated statistical co-occurrence techniques for texture classification of images.
- Intelligent Collaboration and Visualization.
  - * Developed initial library of collaboration middleware for data sharing, coupling and coordination.
  - * Demonstrated real-time capability to discover at least 60% of relevant collaborators using graph matching algorithms.
  - * Demonstrated initial capability for teams to control shared, time-varying visualization models.
  - * Demonstrated initial capability for semantic access to timed event streams and multimedia archives.

• Embeddable Computing. ($15.0M)
- Demonstrated utility of embeddable computing technology in missile/avionics and unmanned undersea vehicle (UUV) real-time testbeds.
- Demonstrated extremely high-density Digital Signal Processing (DSP) packaging and thermal dissipation technologies capable of achieving 1 TFlop/cu. ft.
- Released initial versions of space-time adaptive processing (STAP) algorithm tools and libraries.
- Developed domain-specific development tools with visualization capability and MatLab compatible system generator.

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(U) FY 1999 Program:

- Global Mobile Information Systems. ($18.8M)
  - Demonstrate application support for distributed computing in mobile environments; continuous multi-tier networking across wireless domains; and integrated high data-rate untethered node.
- Systems Environments. ($16.9M)
  - Performance-Driven Compiler and Library Technologies.
    - * Demonstrate experimental scalable structural dynamics application using DARPA sparse matrix library.
  - Load Adaptive Run-time Environments.
    - * Release prototype subsystem supporting adaptive resource allocation and consumption in response to changing workload and resource availability.
- Networking. ($34.3M)
  - Networking Engineering.
    - * Initiate efforts to develop predictive network management based on faster than real-time simulation capability.
    - * Investigate alternative approaches to large scale network management and engineering including self-organizing simulation technology.
    - * Demonstrate reliable service foundation for routing, multicast, and location-aware Enhanced Networking Services on multiple high end workstations.
  - Active Networks.
    - * Extend operation of Active Network technology to traverse ~10 sites of ~10 switches; each using SmartPackets and composite protocols.
    - * Demonstrate node execution environment supporting resource protection, security, and survivability functions.
- Scalable Systems and Software. ($37.5M)
  - Ultrascale Computing.
    - * Conduct system-level design and simulation study of a computation model based on large amorphous arrays; simulate prototype array with >1,000 elements.
    - * Establish role of Nuclear Magnetic Resonance (NMR) technologies in development of ultrascale computing.
  - Data Intensive Computing Systems.

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    * Investigate instruction set extensions and storage components to allow Defense applications to specify whether operations are executed in the central processor or in logic circuits embedded in the memory hierarchy.
  - Scalable Software.
    * Integrate multi-attribute quality-of-service specification language architecture.
    * Demonstrate path-based propagation of quality of service constraints across layer and network boundaries.
- Embeddable Microsystems. ($28.2M)
  - Tactical Signal Processing.
    * Publish benchmarks for embedded signal processing.
    * Demonstrate enabling technologies, including: Discrete Fourier Transform (DFT) chips based on clockless logic, Single Instruction Multiple Datastream (SIMD) and multi-DSP board designs, 4 Gbps channels and high speed configurable interconnect.
    * Develop compiler and code generators to permit retargeting of commercial signal processing tools to suit tactical signal processing environments.
  - Hybrid Information Appliances.
    * Evaluate alternative mechanisms for embedded logic, storage & communications subsystems that incorporate biological materials with potential to achieve size, weight and power reductions of >10 over electronic-only equipment.
    * Investigate communication channels which transduce electrical/optical/magnetic signals to chemical and/or biological processes.
  - Hands-Free Interfaces.
    * Develop algorithms to deal with high noise conditions for speech recognition; demonstrate and evaluate use of dialogue-based architectures within embedded environments.
- Adaptive Computing Architectures. ($27.6M)
  - Debug and validate novel, configurable component technologies and architectures; demonstrate use of adaptive building blocks in wireless radio applications.
  - Demonstrate 100x user-level software performance improvement over commodity microprocessors on challenge problems; release new algorithm design software environment optimized to leverage adaptive technology.
- Defense Technology Integration. ($30.0M)
  - Information Management.

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  * Develop framework for federation of text, image and relational databases.
  * Demonstrate translingual presentation aids for military type documents in English, Korean and a European language.
  * Validate design of secure repository architecture for digital objects up to 100 megabytes in size.
- Intelligent Collaboration.
  * Integrate application-specific and generic collaboration middleware.
  * Develop Adaptive Session Management middleware, leveraging multicasting technology, that adjusts to variations in bandwidth, connectivity, access portal, team composition, and task.
  * Develop tools that enable teams and individuals to: retrieve situation and task relevant information from static and dynamic archives containing a record of experiences from multi-sensory sources; and adjust team dynamics in real-time in response to changes in mission and situation.

(U) FY 2000 Program:

- Global Mobile Information Systems. ($18.9M)
  - Demonstrate generic control channel for multihop radios.
  - Prototype implementation of mobile wireless Asynchronous Transfer Mode (ATM) network.
  - Integrate GloMo simulation models and conduct scenario simulations for 100+ node network.
- Systems Environments. ($16.2M)
  - Release reference implementation of mission-critical QoS architecture.
  - Joint demonstration with AdCon-21 employing C4ISR sensor data for targeting.
- Networking. ($31.7M)
  - Active Networks.
    * Engineering analysis of Active Network performance.
    * Release of prototype Active Network toolkits for end-user stations and network elements including performance goals.
  - Prototype Distributed Systems.
    * Initiate transfer of global scale technologies into distributed operational testbeds.
  - Deeply Networked Systems.
    * Evaluate alternative protocol and addressing structures for deeply networked systems.
- Data Intensive Systems and Software. ($28.5M)
  - Ultrascale Computing.

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    * Prototype implementation of amorphous array.
  - Data Intensive Computing Systems.
    * Design processor in memory VLSI components that support in situ processing of application data.
    * Implement compiler that generates code compatible with processor in memory architecture.
    * Simulate data-intensive systems, demonstrating 10-fold performance improvement on critical DoD applications.
- Embeddable Systems. ($26.8M)
  - Tactical Signal Processing.
    * Implement prototype multiprocessor event collection and analysis system and automated stress test generator for signal processing applications.
    * Develop architecture for tactical signal processing based on deeply networked systems approach.
  - Software Enabled Control.
    * Specify architecture for a hybrid control system that synthesizes the control law approach with computationally-enabled node logic scalable to very large state spaces of 100K+ states.
    * Implement alpha-level prototype of a control system that utilizes active model technology.
- Adaptive Computing Architectures. ($30.7M)
  - Demonstrate self test, diagnosis and reconfiguration to circumvent defective and/or damaged portions of commodity logic components.
  - Demonstrate automated, model-based synthesis of heterogenous Digital Signal Processing (DSP), Application Specific Integrated Circuit/Field Programmable Gate Array (ASIC/FPGA), General Purpose (GP) system designs for large scale systems.
  - Establish Adaptive Computing System challenge problem testbed for experimental development of 1 cubic foot ATR system.
- Defense Technology Integration. ($24.1M)
  - Active System Integration.
    * Specify negotiable behaviors to be supported by active integration software.
    * Identify alternative approaches to location, identification, and determination of capabilities of active components.
  - Autonomous Software.
    * Develop goal tracking requirements for autonomous software.
    * Define challenge problems and metrics for autonomous software.

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(U) FY 2001 Program:

- Global Mobile Information Systems. ($16.5M)
  - Demonstrate multicast services over multihop multimode network.
  - Field demonstration of proxy-enabled distributed computing in mobile environments.
- Systems Environments. ($17.0M)
  - Release prototype distributed object software with real-time QoS management.
  - Demonstrate support for mixed workloads of hard, soft, and non-real-time applications.
- Networking. ($33.7M)
  - Active Networks.
    - * Demonstrate performance improvements of 100% for large multicast sessions based on active suppression of redundant acknowledgement and retransmission messages.
    - * Demonstrate use of active network technology to enhance mobile/nomadic network-based services and protocols.
  - Prototype Distributed Systems.
    - * Continue transfer of global scale technologies into distributed operational testbeds.
    - * Evaluate scalability and performance issues related to mobility, multicast communication and active networking.
  - Deeply Networked Systems.
    - * Prototype implementation of network software and application interfaces.
    - * Identify challenge problems and metrics for deeply networked systems comprising 50-100+ nodes per vehicle.
- Data Intensive Systems and Software. ($27.5M)
  - Ultrascale Computing.
    - * Demonstrate application of amorphous array and artificial nervous system to defense-related problems.
  - Data Intensive Computing Systems.
    - * Prototype fabrication of processor in memory VLSI components that support in situ processing of application data.
    - * Conduct bench experiments to demonstrate that fabricated components achieve performance predicted by simulations.
    - * Conduct bench experiments to demonstrate in situ processing of model-based ATR data at 100,000 ray-patch intersections per second.

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- Embeddable Systems. ($30.9M)
  - Tactical Signal Processing..
    - * Specify standard Application Program Integration (API) for data shaping and data mapping of embedded defense applications; develop prototype of visual program compiler and code generator.
    - * Implement prototype system demonstrating integration of deeply networked sensors and tactical signal processing technologies.
  - Software Enabled Control.
    - * Distribute a software-enabled control toolkit that facilitates development of multi-level, multi-model control systems.
    - * Demonstrate effectiveness of software-enabled control in the context of mission-critical embedded applications such as engine control, flight maneuver, integrated avionics and coordinated control of multiple systems.
- Adaptive Computing Architectures. ($24.5M)
  - Reconfigurable Architectures.
    - * Release beta version of Adaptive Computing Systems (ACS) software including compilers and support for commercial design environments such as MatLab and Khoros; demonstrate 10x improvement in compilation times.
    - * Demonstrate application of ACS technology to challenge problems, including JSTAR-based ATR, RF transient signal analysis and sonar adaptive beamforming.
  - Reconfigurable Kernels.
    - * Investigate alternative approaches to the interfaces and structure of reconfigurable kernels suitable for use in adaptive computing environments.
- Defense Technology Integration. ($33.5M)
  - Active System Integration.
    - * Implement prototype that demonstrates negotiation and behavioral tradeoffs; demonstrate ability to predict and shortcut negotiation.
    - * Demonstrate ability to identify and characterize active components needed for negotiated cooperation and to dynamically form propose/bid hierarchies.
  - Autonomous Software.
    - * Prototype demonstration of goal tracking ability under changing environments.
    - * Select platforms for use in challenge problem implementation.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE
	May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE High Performance and Global Scale Systems, PE 0602301E, Project ST-19

(U) **Program Change Summary:** *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	157.8	193.3	191.6	193.9
Appropriated	154.6	N/A	N/A	N/A
Current Budget	157.8	193.3	176.9	183.6

(U) **Change Summary Explanation:**

FY 1998 Increase reflects reprogramming to partially offset Congressionally mandated undistributed reductions to ensure proper program pricing.
FY 2000 Decrease reflects DARPA Program restructuring and reprioritization.
FY 2001 Decrease reflects DARPA Program restructuring and reprioritization.

(U) **Other Program Funding Summary Cost:** N/A

(U) **Schedule Profile:** N/A

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology, PE 0602301E

COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Software Engineering Technology ST-22	16,609	17,100	17,600	18,100	18,700	19,300	19,300	19,300	Continuing	Continuing

(U) **Mission Description:** Software is key to meeting DoD's increasing demand for high quality, affordable, and timely national defense systems. There is a critical need to rapidly transition state-of-the-art technology and best practices to improve the acquisition, engineering, fielding, and evolution of software-intensive DoD systems. This project funds the technology transition activities of the Software Engineering Institute (SEI) at Carnegie Mellon University. The SEI is a Federally Funded Research and Development Center (FFRDC) sponsored by the Office of the Under Secretary of Defense for Acquisition and Technology. It was established in 1984 as an integral part of the DoD's software initiative to identify, evaluate, and transition high leverage technologies and practices and to foster disciplined software engineering practices by DoD acquisition and life cycle support programs and within the industrial base where the bulk of defense software is produced. The Institute works across government, industry, and academia to: (1) improve current software engineering activities from both management and engineering perspectives; (2) facilitate rapid, value-added transition of technology to practice; and (3) evaluate and calibrate emerging technologies to determine their potential for improving the evolution of software-intensive DoD systems.

(U) The SEI enables the exploitation of emerging software technology by bringing engineering discipline to software acquisition, development, and evolution. The SEI focuses on software technology areas judged to be of the highest payoff in meeting defense needs. FY 1997 and FY 1998 focus areas were: Technical Engineering Practices (including Information Survivability practices, Architecture-centered Software Engineering, and COTS-Based Software Engineering), Enhanced Software Management Capabilities (including Software Process Improvement and Capability Maturity Model Integration (CMMI)), and Accelerating Adoption of High Payoff Software Technologies.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Technical Engineering Practices: Defined and documented administrative process and procedures for global incident response coordination. Processed guides for global incident response coordination to be used by collaborating incident response teams. A vulnerability knowledge base used by response teams was enhanced to support the collection, analysis, and sharing of security incident data. Architectural patterns

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supporting the integration of COTS components have been identified. Attribute-specific survivability patterns for COTS-based architectures and legacy systems were demonstrated. ($9.4M)

- Enhanced Software Management Capabilities: Integrated and enhanced models for software processes, process improvement methods, and analytical capabilities to provide a common base for process assessments and improvement analysis. Released software and systems model under the CMMI framework for stakeholder review. Initiated operation of a repository for DoD software measurement data and risk management experience; released software measurement handbook and risk evaluation guidebook. ($5.4M)
- Adoption of Software Technologies: Developed guidebook for introducing technology change into organizations. Demonstrated potential utility of collaborative process technology for enhancing cooperation in responding to information warfare attacks. Provided software measurement support to all initiative work to ensure performance measures were established. ($1.8M)

(U) FY 1999 Program:

- Technical Engineering Practices: Architecture evaluation guidelines and tradeoff techniques are demonstrated for use with survivable systems; an initial version of a security improvement tool kit developed to help system administrators protect their systems against current and emerging threats; pilot tests of an incident response collaboration support system, including an incident and vulnerability knowledge base, are conducted. Architecture evaluation techniques for COTS-based systems are being used to reduce costs and risk. Training in the development of COTS-based systems is available. ($9.4M)
- Enhanced Software Management Capabilities: Release of the integrated models (software, systems, and IPPD) under the CMMI framework for public review and pilot test. Publication of Version 1 of CMMI support products. CMMI is harmonized with International standards. Initial release of Team Software Process training. ($5.9M)
- Adoption of Software Technologies: Upgraded and expanded measurement information repository is released to define the benefits and costs of technical practices; updated courses in software engineering measurement are packaged to support DoD training needs. ($1.8M)

(U) FY 2000 Program:

- Technical Engineering Practices: Define and document administrative process and procedures for global incident response coordination. Process guides for global incident response coordination are used by collaborating incident response teams. A vulnerability knowledge base used by response teams is enhanced to support the collection, analysis, and sharing of security incident data. Architectural patterns supporting

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the integration of COTS components have been identified. Attribute-specific survivability patterns for COTS-based architectures and legacy systems are demonstrated. ($9.8M)

- Enhanced Software Management Capabilities: Update and release of version 2 of the CMMI products based on Government and industry use and feedback. ($5.9M)
- Adoption of Software Technologies: Develop guidebook for introducing technology change into organizations. Demonstrate potential utility of collaborative process technology for enhancing cooperation in responding to information warfare attacks. ($1.9M)

(U) FY 2001 Program:

- Technical Engineering Practices: Exemplar architectures for survivable systems in use by DoD and industry. Proven strategies for re-engineering legacy systems into product lines. Standard COTS evaluation practices are defined and in use to support the development of COTS-based systems. ($10.0M)
- Enhanced Software Management Capabilities: Transition of CMMI into wide practice in the industry base. ($5.9M)
- Adoption of Software Technologies: Standard practices for adopting technology are in widespread use. ($2.2M)

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	16.6	17.1	17.6	18.1
Appropriated	18.9	N/A	N/A	N/A
Current Budget	16.6	17.1	17.6	18.1

(U) **Change Summary Explanation**:

FY 1998 Decrease reflects realignment of ancillary software efforts so that the core funding of SEI is clearly and separately displayed.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

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APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 2 Applied Research	R-1 ITEM NOMENCLATURE: Computing Systems and Communications Technology, PE 0602301E

COST (In Millions)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Information Survivability ST-24	41,372	54,509	58,640	59,125	78,182	101,128	101,128	101,128	Continuing	Continuing

(U) **Mission Description:** This project is developing the technology required to protect DoD's mission-critical systems against attack upon or through the supporting information infrastructure. These technologies will enable our critical systems to provide continuous correct operation even when they are subject to attack, and will lead to generations of stronger protection, higher performance, and more cost-effective security and survivability solutions scalable to several thousand sites. Technologies developed under this project will be exploited in High Performance and Global Scale Systems (ST-19), Command and Control Information Systems (CCC-01), Information Integration Systems (CCC-02), and in other programs to satisfy defense requirements for secure and survivable systems.

(U) Information Survivability focuses on early prototypes of software technologies leading to protection for large-scale, heterogeneous systems usable over a wide range of performance in diverse threat environments. High confidence network-based systems will include security mechanisms and value-added security services for integration into network-based infrastructure as well as inherent protection mechanisms to allow the system to resist, repel and survive attack. High confidence computing systems will be developed that provide modular security services and mechanisms, provide high reliability for distributed computations, and allow geographically separated parts of an organization to interact as if they shared a common security perimeter. This also includes integrity mechanisms to allow damage to be detected rapidly. Assurance and dynamic integration tools will allow security and survivability to be inserted into legacy systems, and will enable critical systems to reconfigure and survive in the face of detected threat and successful attack.

(U) Survivability technologies will be developed to mitigate national and defense computing infrastructure vulnerabilities that could be exploited by an information warfare enemy. Intrusion detection systems will allow attacks on the defense infrastructure to be detected, the damage to be assessed, and appropriate response to be taken. Technologies will be developed to detect national security threats through correlation and analysis of observed/reported activities.

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(U) **Program Accomplishments and Plans**:

(U) FY 1998 Accomplishments:

- High Confidence Networking. ($9.0M)
  - Demonstrated secure multicast protocol.
  - Completed prototype implementation of agent execution at secure network nodes.
- High-Confidence Computing. ($9.4M)
  - Completed middleware for end-to-end fault tolerant realtime services on Local Area Networks (LAN).
  - Demonstrated integrated security support in prototype extensible operating system.
- Assurance and Integration. ($8.4M)
  - Developed design tools for inferring system-level properties in composed systems.
  - Completed prototype implementation of tools for refinement of secure software architectures.
- Survivability of Large Scale Systems. ($14.6M)
  - Demonstrated techniques for detecting previously unknown attacks.
  - Developed specification for a primitive survivable "immune system" for coordinating response to attacks and intrusions.

(U) FY 1999 Program:

- High Confidence Networking. ($14.1M)
  - Demonstrate secure middleware supporting distributed applications over mobile and wireless networks.
- High-Confidence Computing. ($14.2M)
  - Demonstrate techniques for general pairwise tradeoffs among realtime operations.
  - Evaluate prototype compiler for certifying proof-carrying code.
  - Release operating system prototype supporting efficient, secure nested virtual machines.
- Assurance and Integration. ($10.1M)
  - Complete initial wrapper-generator toolkits.
  - Demonstrate integration of security composition techniques into software engineering tools.
- Survivability of Large Scale Systems. ($16.1M)
  - Develop techniques for diagnosing multi-agent multi-staged attack, through cooperative intrusion detection and reporting.
  - Demonstrate Adaptive Architecture for Survivable Systems.
  - Conduct red team exercise(s) to assess survivability of large scale systems and networks.

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(U) FY 2000 Program:

- High Confidence Network-Based Systems. ($15.0M)
  - Evaluate design principles for highly decentralized systems.
  - Implement prototype of artificial diversity toolkit.
- High Confidence Computing. ($16.0M)
  - Investigate basic integrity mark technology.
  - Prototype demonstration of "push-back" techniques for denial-of-service attacks.
- Assurance and Dynamic Integration. ($10.7M)
  - Complete enhanced wrapper-generator toolkits.
  - Specify initial architecture for Self-Adaptive Flexible Software (SAFER) approach to dynamic integration.
- Survivability of Large Scale Systems. ($16.9M)
  - Initial design for hierarchical reporting structure for intrusion detection systems.
  - Develop experimental methods for filtering less significant events.

(U) FY 2001 Program:

- High Confidence Network-Based Systems. ($15.0M)
  - Develop techniques to isolate corrupted or malicious network entities.
  - Investigate market-based resource allocation mechanisms.
- High Confidence Computing. ($16.0M)
  - Implement alpha prototype toolkit for incorporating integrity techniques into defense software.
  - Design active techniques for traceback and automated response.
- Assurance and Dynamic Integration. ($12.0M)
  - Initial demonstration of introspective fault isolation within SAFER context.
  - Prototype implementation of dynamic integration technology.
- Survivability of Large Scale Systems. ($16.1M)
  - Design protocols to allow detectors and sensors to exchange information on their capabilities.
  - Implement initial peer-to-peer protocols for detection components.

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(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	41.4	54.5	55.7	60.1
Appropriated	41.8	N/A	N/A	N/A
Current Budget	41.4	54.5	58.6	59.1

(U) **Change Summary Explanation**:

FY 1998 Change reflects minor program repricing.
FY 2000-01 Changes reflect minor program repricing.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology, PE 0602301E					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Joint Infrastructure Protection ST-26	0	69,900	0	0	0	0	0	0	0	N/A

(U) **Mission Description:** The President's Commission on Critical Infrastructure Protection was established by Executive Order in July 1996 to examine the physical and national cyber defense threats to (and vulnerabilities of) critical infrastructures in the United States. As a result, this commission increased the DoD research and development investment for information assurance research and "other areas" of infrastructure protection (i.e., improved system and network protection, intrusion monitoring and detection systems, information collection technologies, and data reduction and analysis tools). This initiative is expected to be organized around four general thrusts; developing technologies to build hardened information systems and networks that: (1) have strong barriers to attack, (2) can detect malicious and suspicious activity, (3) can isolate and repel malicious and suspicious activity, and (4) can guarantee minimum essential continued operation of critical system functions in the face of concerted information attacks. It is further expected that, because of its extreme timeliness and importance, this initiative will be conducted in very close partnership, if not jointly, with the Military Departments and with the full involvement of the Chief Information Officer (CIO) of each Service.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments: New Start in FY 1999.

(U) FY 1999 Program:

- Create information warfare indications and warning tools. ($15.0M)
- Create intrusion detection effectiveness testbed and flexible tools & metrics to assess CII components. ($7.0M)
- Develop and harden adaptive system response to attack. ($7.0M)
- Improve system survivability through decentralized system organizations. ($5.0M)
- Improve and harden network security tools to address denial of service. ($8.9M)
- Develop security solutions for dynamic databases and object systems. ($7.0M)
- Harden and integrate cooperating intrusion detectors. ($5.0M)
- Demonstrate and transition infrastructure protection technologies to national critical infrastructure systems such as the military's command and control systems and to the constituent commercial and customized components that comprise such systems. ($15.0M)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE
	May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology, PE 0602301E, Project ST-26

(U) FY 2000 Program: N/A

(U) FY 2001 Program: N/A

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	0	69.9	0	0
Appropriated	N/A	N/A	N/A	N/A
Current Budget	0	69.9	0	0

(U) **Change Summary Explanation**: N/A

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 2 Applied Research	R-1 ITEM NOMENCLATURE: Biological Warfare Defense; PE 0602383E, R-1 #13

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Biological Warfare Defense Program BW-01	60,805	88,000	92,500	98,000	101,000	105,800	106,800	107,800	Continuing	Continuing

(U) **Mission Description:** The Biological Warfare Defense program is budgeted in the Applied Research budget activity (BA-2) because its focus is on the underlying technologies associated with pathogen detection and remediation. Today, there is a tremendous mismatch between the magnitude of the biological warfare threat and the Department's ability to adequately respond. The widespread availability of bacterial, viral, and toxin stocks; minimal developmental cost and scientific expertise required; and abundance of weaponization potential comprise a sinister threat. The single largest concern, however, is from the exploitation of modern genetic engineering by adversaries to synthesize "super pathogens." Recent dramatic developments in biotechnology, which this program will leverage, promise to eliminate this mismatch. This program funds projects supporting revolutionary new approaches to biological warfare (BW) defense.

(U) Efforts to counter the BW threat include developing barriers to block entry of pathogens into the human body, pathogen countermeasures to stop pathogen virulence and to modulate host immune response, medical diagnostics for the most virulent pathogens and their molecular mechanisms, biological and chemically-specific detectors, and consequence management tools. Program development strategies include collaborations with pharmaceutical, biotechnology, government, and academic centers of excellence.

(U) Pathogen countermeasures (e.g., Anti-Virals/Immunizations, Anti-Bacterials/Anti-Toxins, Multi-Purpose, and External Protection) under development include: (1) multi-agent therapeutics against known, specific agents and (2) therapeutics against virulence pathways shared by broad classes of pathogens. Specific approaches include modified red blood cells to sequester and destroy pathogens, modified stem cells to detect pathogens and produce appropriate therapeutics within the body, identification of virulence mechanisms shared by pathogens, development of therapeutics targeting these mechanisms, efficacy testing in cell cultures and animals, and advanced non-toxic decontamination strategies.

(U) In the early stages, many illnesses caused by BW agents have flu-like symptoms and are indistinguishable from non-BW related diseases. Early diagnosis is key to providing effective therapy. The advanced diagnostics efforts will develop the capability to detect the presence of infection by biological threat agents, differentiate from other significant pathogens, and identify the pathogen, even in the absence of recognizable signs and symptoms (when the pathogen numbers are still low).

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, Project BW-01

(U) The ability to detect biological warfare agents on the battlefield in real time with no false alarms is a crucial requirement. To address this need, the program is creating more efficient and effective miniature sampling technologies that concentrate contaminated air and enhance the ability to capture biological warfare agents. The program is developing a new range of antibodies and "designer small molecules" to bind specific agents (to replace the lower affinity antibodies currently used). In order to detect that the binding of an agent has occurred, the event must be "magnified." Traditionally, this is done by tagging the antibody molecule with a fluorescent probe. This program is replacing the noise-plagued fluorescent tags with Up-Converting Phosphors with the sensitivity to detect a single binding event, minimizing the size of the sample required, saving time, and decreasing the number of false positive alarms. The use of fluids as a requirement for biological agent detection is also being eliminated and replaced by a miniaturized (shoe box-size) time-of-flight mass spectrometer. Development of a bacterial biochip to identify genus and species without multiplying the DNA by the polymerase chain reaction (PCR) is also under development, thereby saving at least 20 minutes in time to identification. Additional efforts are focusing on the construction of molecular, cellular, and multicellular sensors for the rapid detection of biological threats. These cellular and tissue-based sensors have the ability to respond to both known and unknown threats and determine live vs. inactivated threat status.

(U) Mission effectiveness requires rapid, correct medical responses to biological weapon threats or attacks. A portion of this project will provide comprehensive protocols to protect or treat combatants by using current and emerging biological countermeasures. It will provide accelerated situational awareness for biological warfare events by detecting exposure to agents through an analysis of casualty electronic theater medical records and will locate and determine the most effective logistical support for providing appropriate treatment and pathogen-specific resources required to mitigate effects of the attack.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Pathogen Countermeasures. ($43.1M)
  - Optimized the detection of specific pathogens by stem cells (in cell culture).
  - Determined the impact of modified red blood cells on vascular and immune systems.
  - Defined animal models in which to test the efficacy of modified red blood cells to defend against pathogens.
  - Developed enzymes or other active molecules which can be attached to the surface of red blood cells to detect and destroy pathogens.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, Project BW-01

- Established a portfolio of strategies to:
  * inhibit the expression of disease-causing (virulence) factors by pathogens.
  * disrupt the disease-causing (virulence) communications between pathogens.
  * modulate the body's response to the presence of a pathogen.
  * assess feasibility of novel polymeric materials to protect against pathogen exposure.
- Assessed the feasibility of an array based instrument (and other novel technologies) for multi-agent pathogen diagnosis in medical samples.

• Sensors. ($9.7M)
- Developed a hierarchical database of mass signatures for use in detecting selected bacteria with a mass spectrometer.
- Investigated methods for determining biological warfare agent bacterial and viral viability (agent live or dead).
- Demonstrated the feasibility of using giant magnetoresistance for the detection of magnetic bead-tagged pathogens.
- Fabricated and tested a wick device, an integral sample pump, and a reagent reservoir system suitable for use in a handheld Up-Converting Phosphor detector.
- Developed a bio-chip for rapid pathogen identification.
- Identified limiting performance variables for cells in tissue based detection schemes.

• Consequence Management. ($8.0M)
- Demonstrated a biological warfare Anchor Desk that provides agent-specific biological warfare (BW) situational awareness, decision and execution support with linkages to the Logistics Anchor Desk (LAD) for BW-specific logistical information.
- Developed agent-specific "software antibodies" for detection, protection, and treatment directives to medical personnel for BW threats that will decrease response time.
- Developed quantitative measures of operational assessment using Medical Readiness Indicators (metrics based indicators of individual and unit level readiness) and realistic BW training algorithms to improve the medical response to a biological warfare incident.
- Demonstrated Enhanced Consequence Management Planning and Support System (ENCOMPASS) during BIO 911 and other exercises for command and control of biological warfare incidents.

(U) <u>FY 1999 Program</u>:

• Anti-Virals/Immunizations. ($18.0M)
- Develop a modified stem cell which can both detect and produce a prophylactic/therapeutic response to a pathogen (in cell culture).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 2 Applied Research	R-1 ITEM NOMENCLATURE: Biological Warfare Defense; PE 0602383E, Project BW-01

- Determine (in-vitro) toxicity of modified stem cell-produced therapeutics.
- Create techniques to rapidly develop immunization strategies against bacterial and viral pathogens and toxins.

• Anti-Bacterials/Anti-Toxins. ($15.0M)
- Develop and test (in-vitro) cellular platforms for toxin destruction and toxin binding decoys.
- Demonstrate selected strategies (in cell culture) to:
  * inhibit the expression of disease-causing (virulence) factors by pathogens.
  * disrupt the disease-causing (virulence) communications between pathogens.
  * modulate the body's response to the presence of a pathogen.

• Multi-Purpose. ($12.0M)
- Define animal models in which to test the efficacy of modified stem cells to prevent disease.
- Demonstrate in laboratory animals the efficacy of modified red blood cells to eliminate pathogens from the blood for the purpose of potential defense against biological warfare (BW) agents.
- Determine pathogen detection and elimination efficacy for modified red blood cells with enzymes or other active molecules attached to their surfaces.

• External Protection. ($8.0M)
- Develop polymeric materials for pathogen protection.
- Develop a nonspecific surfactant agent to neutralize biological threat agents.

• Advanced Diagnostics. ($12.0M)
- Determine appropriate bodily sample types (blood, saliva, sputum, etc.) to use for diagnosis.
- Determine which non-BW pathogens must be screened against because they mimic early BW symptoms.
- Begin identification of probes to be used in diagnosis systems.
- Evaluate feasibility of novel technologies and sampling strategies, such as detecting bodily responses indicative of infection.

• Sensors. ($15.0M)
- Continue development of air sampling technology for airborne biological materials.
- Determine chemotaxonomic biomarkers for selected viral substances for detection in the mass spectrometer.
- Demonstrate replacement of a surface-bound antibody with a "designer" small molecule for high affinity pathogen capture.
- Complete Up-Converting Phosphors (UCP) detection system and field test.
- Modify the prototype of a miniature biodetection system following Dugway Proving Ground test results.
- Examine and select strategies to stabilize cell systems for long-term functional response.
- Select cell types for the development of tissue based sensors.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, Project BW-01

- Demonstrate the ability to modify the duty cycle of a cellular response in single cell and tissue based sensors.
- Demonstrate performance of a single cell sensor.

• Consequence Management. ($8.0M)
- Complete development of consequence management software tools.
- Perform additional field test of biological warfare (BW) defense attack response planning tool and electronic watchboard.
- Demonstrate interactivity and synergism of software tool suite.
- Transition software antibodies, biological warfare knowledge base, BW Medical Readiness Indicators, and maintenance tools to the Services.

(U) FY 2000 Program:

• Anti-Virals/Immunizations. ($20.0M)
- Identify bacteriophage nucleic acids with potential for immunomodulatory activity against multiple viruses.
- Demonstrate (in-vivo) the efficacy of anti-viral peptides derived from hematopoietic stem cells.
- Demonstrate (in-vitro) the efficacy of anti-viral immune cells derived from hematopoietic stem cells.
- Develop a method of mucosal immunization based upon high level expression of pathogen antigens and epithelial transport molecules in transgenic plant cells.
- Develop technologies for rapid design and development of new vaccines against novel pathogens.

• Anti-Bacterials/Anti-Toxins. ($17.8M)
- Develop faster, safer, and more economical production systems for anti-bacterials and anti-toxins.
- Demonstrate (in-vivo) toxin-blocking antibodies and toxin binding decoys.
- Demonstrate (in-vitro) the efficacy of a broad spectrum pathogen antagonist.
- Develop (in-vitro) broad spectrum, superantigenic, anti-toxin antagonists and vaccines.

• Multi-Purpose. ($13.0M)
- Develop synthetic polymer complements for pathogenic antigens and virulence factors.
- Identify monomeric and dimeric DNA and RNA binding molecules as novel countermeasures against multiple pathogens.
- Identify polyvalent inhibitors for inhibiting pathogens on the surface of the target cells in vivo.

• External Protection. ($9.0M)
- Develop decoy molecules that will prevent the adhesion of multiple pathogenic toxins or viruses in vivo.
- Demonstrate (in-vivo) a non-specific surfactant agent to neutralize biological threat agents.

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- Advanced Diagnostics. ($15.0M)
  - Continue identification of probes to be used in diagnosis systems, and begin testing of probe panels in the laboratory.
  - Identify and evaluate promising novel technologies for development into new diagnostics or devices.
  - Identify one or more promising strategies for rapid detection based on bodily responses or other biomarkers to provide early indication of infection or exposure.
  - Determine feasibility of engineering red blood cells to detect and signal pathogen presence in the body.
  - Determine feasibility of rapid single molecule DNA sequencing.
- Sensors. ($17.7M)
  - Complete, test, and verify first-generation prototype of live agent bio-chip sensor.
  - Complete development of air sampling technology for airborne biological material.
  - Continue development of effective and rapid chip-reading capability.
  - Continue the development of unique signatures for bio-agents in mass spectrometry identification.
  - Develop biosensor technology for next-generation (bioengineered) threat agents.
  - Construct cell and tissue engineered configurations to enhance optical or electrical signal output from the sensor.
  - Optimize electronic interfaces for optical and electrical reporting from cell and tissue based sensors.
  - Investigate optimal system designs for deployment of a single cell and tissue based biosensors which incorporate environmental sampling, microfluidics, and automated detection.
  - Evaluate cell and tissue based informatics from temporal and spatial signals in cell and tissue sensor.

(U) FY 2001 Program:

- Anti-Virals/Immunizations. ($21.5M)
  - Demonstrate the use of bacteriophage nucleic acids as immunomodulators against multiple viruses.
  - Demonstrate (in-vivo) the efficacy of anti-viral immune cells derived from hematopoietic stem cells.
  - Validate (in-vivo) a method of mucosal immunization based upon high level expression of pathogen antigens and epithelial transport molecules in transgenic plant cells.
  - Test and validate (in-vivo) the protective efficacy of vaccines and antibodies produced by plant cells against pathogens.
  - Demonstrate the efficacy of the rapid and efficient delivery of pathogen antigens via new genetic vaccine vectors.
- Anti-Bacterials/Anti-Toxins. ($19.5M)
  - Demonstrate surface expression of specific enzyme molecules for the rapid inactivation of various pathogens.

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APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 2 Applied Research	R-1 ITEM NOMENCLATURE: Biological Warfare Defense; PE 0602383E, Project BW-01

- Demonstrate (in-vivo) toxin-blocking antibodies and toxin binding decoys.
- Demonstrate (in-vitro) the efficacy of a broad spectrum pathogen antagonist.
- Validate (in-vivo) broad spectrum, superantigenic, anti-toxin antagonists and vaccines.

• Multi-Purpose. ($14.0M)
- Demonstrate synthetic polymer complements for pathogenic antigens and virulence factors.
- Demonstrate (in-vitro) the efficacy of monomeric and dimeric DNA and RNA binding molecules as novel countermeasures against multiple pathogens.
- Validate polyvalent inhibitors for blocking pathogens on the surface of the target cells in vivo.
- Continue the development and expansion of gene-based antimicrobial therapeutics.

• External Protection. ($10.0M)
- Develop a novel architectural approach for the manufacture of materials that are effective in blocking pathogens and limiting disease.
- Demonstrate a non-aqueous advanced decontamination method.

• Advanced Diagnostics. ($15.0M)
- Test probe panels in relevant sample types.
- Test, in model systems, one or more of the most promising candidate strategies for rapid detection based on bodily responses or other biomarkers to provide early indication of infection or exposure.
- Demonstrate, in the laboratory, feasibility of engineering red blood cells to detect and signal pathogen presence in the body.
- Evaluate feasibility of additional strategies for direct identification or detection of infection without sample taking.
- Demonstrate feasibility of rapid single molecule DNA sequencing in a model system.

• Sensors. ($18.0M)
- Continue development of effective and rapid chip-reading capability.
- Continue the development of unique signatures for bio-agents in mass spectrometry identification.
- Continue development of advanced alternative technologies for live vs. dead bio-agent identification using peptides and other molecules.
- Continue development of technologies required for next-generation miniature biological detectors.
- Engineer a deployable prototype cell and tissue sensor for field testing.
- Demonstrate enhanced signal output from engineered cells and tissue based sensors.
- Integrate information from cell and tissue sensors with user interfaces for predictive responses.

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DATE: May 1998

APPROPRIATION/BUDGET ACTIVITY
RDT&E, Defensewide
BA 2 Applied Research

R-1 ITEM NOMENCLATURE
Biological Warfare Defense
PE 0602383E, Project BW-01

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	60.8	88.0	77.3	74.0
Appropriated	57.4	N/A	N/A	N/A
Current Budget	60.8	88.0	92.5	98.0

(U) **Change Summary Explanation**:

FY 1998 Increase reflects repricing of pathogen countermeasures and sensors efforts.
FY 2000 Increase reflects expansion of efforts in Pathogen Countermeasures, Sensors and Advanced Diagnostics.
FY 2001 Increase reflects expansion of efforts in Sensors, Advanced Diagnostics, and External Protection/Decontamination and Neutralization.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 2 Applied Research	R-1 ITEM NOMENCLATURE: Tactical Technology; PE 0602702E, R-1 #15

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Tactical Technology	**148,331**	**188,995**	**176,703**	**195,597**	**239,658**	**270,734**	**280,734**	**290,734**	**Continuing**	**Continuing**
Naval Warfare Technology TT-03	20,783	16,796	11,553	14,172	27,172	27,172	27,172	27,172	Continuing	Continuing
Advanced Land Systems Technology TT-04	20,817	35,000	45,750	46,686	55,686	60,886	60,886	60,886	Continuing	Continuing
Advanced Targeting Technology TT-05	0	0	0	0	10,000	38,300	48,300	58,300	Continuing	Continuing
Advanced Tactical Technology TT-06	55,091	71,534	57,767	55,728	61,800	68,728	68,728	68,728	Continuing	Continuing
Aeronautics Technology TT-07	20,235	34,000	41,000	59,011	55,000	55,648	55,648	55,648	Continuing	Continuing
Advanced Logistics Technology TT-10	21,214	21,665	10,633	10,000	20,000	20,000	20,000	20,000	Continuing	Continuing
Joint Logistics ACTD TT-11	10,191	10,000	10,000	10,000	10,000	0	0	0	0	N/A

(U) **Mission Description**: This program element is budgeted in the Applied Research Budget Activity because it supports the advancement of concepts and technologies to enhance the next generation of tactical systems. The Tactical Technology program element funds a number of projects in the areas of Naval Warfare, Advanced Land Systems, Advanced Targeting, Advanced Tactical, Aeronautics, and Advanced Logistics technologies.

(U) The Naval Warfare Technology project is focusing on: Command, Control, Communications and, Intelligence/Synthetic Environments (C3I/SE), Digital Terrain Mapping, High Energy Density Materials, Reduced Drag/Fast ship and Payload Submarine. In the C3I/SE program, advanced information technologies are being integrated into advanced prototype systems to provide improved battlefield awareness and dominance to mobile command centers in the field. Digital Mapping efforts are focused on demonstrating a lightweight, broadband phased-array antenna and altitude measuring system that will produce real-time 3D maps of littoral environments. The High Energy Density

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Materials program is exploring high risk/high pay-off breakthroughs in missile propellants and explosives technologies. The Reduced Drag/Fast Ship program focuses on the development of technologies that enable the design of efficient, high speed sealift ships. The Large Payload Submarine effort will explore submersible platforms designed to maximize payload capacity.

(U) The Advanced Land Systems Technology project is developing technologies for contingency missions and military Operations-Other-Than-War (OOTW) to make U.S. combat forces more deployable, effective, survivable, and affordable. The SLID program will develop and test a system for providing protection against missiles and projectiles with explosive warheads. The Advanced Fire Support Systems program will provide rapid response and lethality associated with gun and missile artillery, thereby increasing survivability, yet requiring fewer personnel and less logistical support. The Counter-artillery Force Protection program will explore advanced sensors, munitions and deployment concepts to counter evolving threats. The Unexploded Ordnance Detection program will develop sensors for the chemically specific detection of explosives or other chemicals, comparable to the effectiveness of canine olfaction detection. The Glass Turret program will address vehicle survivability and targeting functions for future combat vehicles. The Rapid Combat Insertion program will develop systems for the rapid high survivability insertion of material.

(U) The Advanced Tactical Technology project is exploring the application of compact lasers; compact high-density holographic data storage and high performance computational algorithms to enhance performance of radars, sensors, communications, and electronic warfare and target recognition and tracking systems. In addition, the project funds technologies which focus on precision optics components for critical DoD applications, tactical landing systems, miniature air-launched decoy systems, affordable rapid response missile demonstrations, and adaptive reasoning and control.

(U) The Aeronautics Technology project will develop and demonstrate a new family of Micro-Aerial Vehicles (MAVs). The MAVs will be an order of magnitude smaller than any operational UAV and will be useful in a wide variety of military missions from covert imaging and chemical/biological agent detection to communication enhancement. The Micro Adaptive Flow Control effort, vertical take-off and landing unmanned air vehicle, and small-scale propulsion system concepts are also funded within this project.

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(U) The Advanced Logistics project is investigating and demonstrating technologies that will make a fundamental difference in transportation and logistics. The program will define, develop, and demonstrate fundamental enabling technologies that will permit forces and sustainment materiel to be deployed, tracked, refurbished, sustained, and redeployed more effectively and efficiently than before.

(U) The Joint Logistics Advanced Concepts Technology Demonstration (ACTD) is a program that will provide hands-on demonstrations of existing and evolving logistics tools to facilitate their introduction into the service logistics community. Initial efforts will integrate existing tools that exploit near-term capabilities that can operate within the Global Combat Support System. Focus areas for the Joint Logistics ACTD correspond to Commander-In-Chief (CINC) and Service requirements to develop Joint Decision Support Tools (JDST).

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology, PE 0602702E					
COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Naval Warfare Technology TT-03	20,783	16,796	11,553	14,172	27,172	27,172	27,172	27,172	Continuing	Continuing

(U) **Mission Description:** The Naval Warfare Technology project develops advanced technologies for application to a broad range of naval requirements. The enabling technologies include: Command, Control, Communications, and Intelligence/Synthetic Environments (C3I/SE) for littoral warfare; all weather interferometric sensors for precision 3-D characterization and surveillance of littoral environment for smart Naval Fire Support (NFS) weapons; investigations into High Energy Density Materials (HEDM) for advanced explosives and propellants; innovative approaches to drag reduction and dynamic lift to enable the design of efficient, high-speed logistics ships; and innovative design concepts for expanding the envelope of operational capabilities for submersible platforms.

(U) In the Command, Control, Communication, and Intelligence/Synthetic Environment (C3I/SE) area, advanced information technologies are being integrated and applied to provide improved battlefield awareness and battlefield dominance to mobile command centers in the field (e.g., Force Commanders, Commander Joint Task Force (CJTF), and deployed Joint Special Operations Task Force (JSOTF) Commanders). The advanced prototype systems developed under this program integrate the latest technologies in high-bandwidth communications, object oriented information system, collaborative planning, intelligent database access, image processing, data exploitation, and high performance computing to address the unique (quick reaction and realtime execution) requirements of forward deployed, mobile commanders. The program developed systems design for collaborative crisis understanding and mitigation, developing tools and systems necessary to recognize, understand, forecast, and defuse potential crisis situations. The Genoa Project will substantially reduce the time necessary to form teams, analyze crisis data, and develop and brief response options. This effort is focused on the National Command Authority, National Security Council, and the National Military Command Center.

(U) 3-D High-Resolution Digital Terrain Mapping will support the Naval Fire Support (NFS) missions in the littoral environment by development of advanced 3-D radar technologies which will enable the Commander Joint Task Force (CJTF) to obtain precise realtime 3-D maps of littoral environments. These precision 3-D maps provide accurate position information of all objects in the littoral theater and will be required for next generation smart munitions and surveillance systems. All weather interferometric sensors for precision 3-D characterization and surveillance of littoral environment will require the development of broadband planar antenna active arrays, precision attitude measurement systems using inertial navigation systems tightly coupled with space based precision frequency and time sources. This effort will also develop and demonstrate advanced radar waveforms and processing algorithms required

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for precision geolocation by standoff sensors, particularly bias removal by multi-scene fusion, and optimal resource allocation using dynamic programming.

(U) The High Energy Density Materials (HEDM) program fosters high-risk/high payoff efforts which could result in major breakthroughs in missile propellant and explosives technologies applicable to a wide variety of tactical and strategic military systems. The HEDM project will investigate the synthesis of new molecules capable of providing orders of magnitude increases in explosive and/or propulsive energy per unit weight. The stability and energy content of several such molecules have been predicted theoretically. The molecules will contain only nitrogen atoms or a very high percentage of nitrogen atoms, a situation which makes their production and use environmentally friendly. The potential benefits include: thermodynamic properties which could result in their having two-to-six times as much propulsive/explosive energy as current state-of-the-art operational materials, the "greening" of production and use, and reduction of delectability. Missile systems with size constraints could have increased range, maneuverability for flexible targeting, and/or increased kill effectiveness due to improvements in both the propellant's thrust and the warhead's lethality (per weight and volume). The program builds on theoretical work previously sponsored by other DOD organizations and provide some high risk excursions into materials which are theoretically possible but for which there is no currently known defined synthetic route.

(U) The Reduced Drag/Fast Ship program is focused on the development and demonstration of technologies that will enable the design of efficient, high speed ships (greater than 75 knots) for a rapid response, long range (approximately 10,000 nautical miles unrefueled), sealift capability (2,500 tons cargo). While a hydrofoil type of architecture appears to offer the most promise, cost effective high speed sealift will require a significant increase over the currently achievable fuel efficiency. Therefore, this program will emphasize drag reduction, particularly, the use of air injection to reduce the level of frictional drag. Both numerical analysis and tow tank experiments will be used to determine the extent to which drag can be reduced.

(U) Current submarine designs are significantly limited in the quantity and types of payloads that can be accommodated. Recently completed high level studies have highlighted the critical need to address these limitations if the stealth inherently available to submerged platforms is to remain tactically relevant in the future. The Large Payload Submarine (LPS) effort is intended to explore the operational and technical challenges and opportunities posed by submersible platforms designed specifically for the objective of maximizing payload capacity and variety. Implications to the design of the platform, associated combat systems, and supporting ordnance will be considered.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology, PE 0602702E, Project TT-03

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Continued systems development and initiated development of a tool for rapid, collaborative option development, evaluation, and presentation; demonstrated and evaluated retrieval agents; demonstrated use of access templates and profiles; evaluated filters. Demonstrated the ability to navigate several of the most important, crisis-related databases for acquiring information on a simulated crisis. ($3.2M)
- Evaluated ability to quantify centers-of-gravity and pressure points for option development, and demonstrated modeling capabilities at Joint Task Force ATD/Global Command and Control System Insertions. Demonstrated crisis presentation capability for prioritizing policy and plans at National Security Council/National Military Command Center and supporting intelligence agencies. ($4.4M)
- Demonstrated the capabilities of Digital Terrain Elevation Data (DTED) 5 using multiscene Interferometric Synthetic Aperture Radar (IFSAR) fusion, and interwoven IFSAR/Ground Moving Target Indicator (GMTI) tasking. ($1.6M)
- High Energy Density Materials (HEDM): Initiated focused synthesis; established parallel supporting efforts in theoretical chemistry, kinetics and thermodynamics. ($2.0M)
- The following activities were funded by Congressional addition to the FY 1998 President's Budget:
  - Center of Excellence for Research in Ocean Sciences (CEROS) - Continued most promising ocean sciences efforts at the CEROS. ($6.8M)
  - Simulation - Based Design (SBD) - Transferred to Defense Logistics Agency. ($2.8M)

(U) FY 1999 Program:

- Demonstrate initial operational capability of the data retrieval and visualization capability, initial operational capability of the crisis modeling capability, and begin installation of modeling capability and integration with data retrieval capability at CIA/NMJIC. Begin installation and integration of advanced presentation capability. ($6.6M)
- Complete initial design and initiate fabrication of a 3-D, high-resolution Digital Terrain Mapping system employing planar array covering 8 to 18 GHz in a low-cost, lightweight conformal structure, attitude-measurement system, and reconstruction algorithms. ($4.0M)
- Develop a real time littoral targeting network to registrate Synthetic Aperture Radar (SAR) against Digital Terrain Elevation Data (DTED) data to remove pointing errors and elevation ambiguity, track, ID, and handover target co-ordinates. Conduct an airborne demo of this precision littoral targeting system. ($2.0M)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE
	May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology, PE 0602702E, Project TT-03

- Continue initial synthesis and fundamental support activities for High Energy Density Materials (HEDM); develop methods to scale-up production. ($2.0M)
- Conduct utility and performance study of modular wet submarine payload options, including the operational and technical feasibility of small submersible platforms. ($1.2M)
- Initiate conceptual designs for a small submersible platform and the associated mothering approach. ($1.0M)

(U) FY 2000 Program:

- Scale up High Energy Density Materials (HEDM) development to gram quantities and experimentally verify functional properties. ($4.5M)
- Perform design trade studies; test and evaluate drag reduction technologies; begin integration of results into a high speed ship design. ($3.0M)
- Commence conceptual design of a Large Payload Submarine (LPS); identify potential supporting technology risks and opportunities. ($4.1M)

(U) FY 2001 Program:

- Complete evaluation and testing of drag reduction technologies; complete low drag, high speed, ship design and estimate resulting performance. ($11.0M)
- Continue HEDM development and functional property verification; assess HEDM system applications. ($3.2M)

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	20.8	16.8	11.6	14.2
Appropriated	20.7	N/A	N/A	N/A
Current Budget	20.8	16.8	11.6	14.2

(U) **Change Summary Explanation**:

FY 1998 Increase is due to minor program repricing.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology, PE 0602702E, Project TT-03

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE May 1998		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research				R-1 ITEM NOMENCLATURE Tactical Technology, PE 0602702E						
COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Land Systems Technology TT-04	20,817	35,000	45,750	46,686	55,686	60,886	60,886	60,886	Continuing	Continuing

(U) **Mission Description:** This project is developing technologies for contingency missions and military Operations-Other-Than-War (OOTW) to make U.S. combat forces more deployable, effective, survivable, and affordable. This project supports seven main efforts: Small Low-Cost Interceptor Device (SLID); Advanced Fire Support Systems; Counter-artillery Force Protection (CFP); Unexploded Ordnance Detection; Alternatives to Antipersonnel Landmines; the Glass Turret (GT); and Rapid Combat Insertion (RCI).

(U) The SLID program is developing and testing a system which protects threatened systems against missiles and projectiles with explosive warheads. This system will detect, track and intercept threats such as anti-armor missiles, mortars, artillery, and top-attack sensor fused munitions at a standoff distance sufficient to render them ineffective. Applications for the SLID system include: Self-defense of vehicles; defense of high value fixed sites such as command centers, parked aircraft and radars; and, with further development, naval platforms and low-speed aircraft.

(U) The Advanced Fire Support Systems program will develop and test containerized, platform independent land attack weapon systems. These systems will provide rapid response and lethality in packages requiring significantly fewer personnel, decreased logistical support, lower life-cycle costs, and having increased survivability compared to current gun and missile artillery. These systems will allow the military to more completely capitalize on recent advances in military doctrine and infrastructure, such as the ongoing digitization of the Army. The program will develop and demonstrate highly flexible systems including a guided projectile/munition, a remotely commanded self locating launcher, and a command and control system compatible with military doctrine.

(U) The Counter-artillery Force Protection (CFP) program will develop concepts for defending forces and civilian enclaves against air threats including high rate of fire missile artillery carrying submunitions. The program will explore advanced sensors, munitions and deployment concepts to counter this evolving threat. System concepts will be developed and analyzed.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology, PE 0602702E, Project TT-04

(U) The Unexploded Ordnance (UXO) Detection program will develop sensors for the chemically specific detection of explosives or other chemicals characteristic of land mines and/or shallowly buried UXOs. The sensors developed under this program will provide soldiers with the effectiveness of canine olfaction detection without the logistics and other constraints imposed by the use of live animals. These chemically specific sensors will work either singly or in conjunction with other technologies such as the hyperspectral mine detector, developed under the Small Unit Operations (SUO) program that exploit different physical features.

(U) DARPA will develop technologies that provide alternatives to antipersonnel landmines (APL). The systems developed under this program will provide our warfighters with enhanced capabilities that obviate the need for mines. Technologies considered include: Self-healing anti-tank (AT) minefields (that allow the protection of AT mines without the use of APL), tags with minimally guided munitions that allow the compression of critical timelines and distance constraints imposed by conventional indirect and direct fire approaches, and advanced spoofing concepts that will permit sophisticated battlefield shaping capabilities.

(U) The Glass Turret (GT) program will be an integrated sensor system which performs both vehicle survivability and targeting functions for future combat vehicles. The program will take radar and electro-optic technology developed under the SLID program and extend its capabilities to include other required functions, such as reconnaissance, surveillance and targeting. The program will also address display systems and human factors. Particular attention will be placed on minimization of signatures from both active and passive sensors.

(U) The Rapid Combat Insertion (RCI) program will develop systems for the rapid, high survivability insertion of material and, in principal, personnel. The systems would be deployed from aircraft at safe distance from the desired delivery point and would deliver their contents to precise locations. The program will look to significantly increase range, speed, payload, and survivability over current parachute and parafoil based systems.

(U) **Program Accomplishments and Plans**:

(U) FY 1998 Accomplishments:

- Small Low-Cost Interceptor Device (SLID). ($6.9M)
  - Completed development leading to live-on-live Small Low-Cost Interceptor Device (SLID) testing.
- Unexploded Ordnance Detection. ($10.9M)
  - Demonstrated laboratory scale system for chemically specific detection of land mines.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology, PE 0602702E; Project TT-04

- Advanced Fire Support System (AFSS). . ($3.0M)
  - Conducted initial activities in the Advanced Fire Support System development.
  - Conducted concept and requirements analysis for platform independent and unmanned missile artillery packages.
  - Developed baseline concept designs.

(U) FY 1999 Program:

- Small Low-Cost Interceptor Device (SLID). ($8.0M)
  - Complete vehicle self protection testing.
  - Transition ground vehicle active protection technology to Army.
  - Develop active and passive survivability capabilities against unitary munitions for both vehicle and ground forces, including extension of SLID protection range for application to high value fixed sites.
- Unexploded Ordnance Detection. ($12.0M)
  - Field demonstration of prototype chemically specific land mine detector paired with other sensors as appropriate.
- Advanced Fire Support System (AFSS). ($8.0M)
  - Develop detailed designs for the Advanced Fire Support System architecture.
  - Conduct evaluations and testing of high risk and critical components.
  - Define system demonstration objectives.
- Counter-artillery Force Protection (CFP). ($5.0M)
  - Define one or more system architectures, including sensors, munitions and deployment, to meet the mission needs for enclave protection against missile artillery.
- Rapid Combat Insertion (RCI). ($2.0M)
  - Begin development of material insertion system.
  - Define concepts for personnel insertion systems.

(U) FY 2000 Program:

- Glass Turret (GT). ($5.0M)
  - Begin development of integrated radar and electro-optic suite.
  - Begin development of integrated display system.
- Advanced Fire Support System (AFSS). ($22.8M)
  - Complete detail design for AFSS objective demonstration system, including launch, fire control, and each of the demonstration flight systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology, PE 0602702E, Project TT-04

- Develop and test component hardware and software for AFSS.
- Initiate hardware-in-the-loop tests.
- Plan and initiate limited objective flight tests.

• Alternatives to Antipersonnel Landmines. ($12.0M)
- Develop technologies that obviate the military missions served by antipersonnel landmines. Complete detailed design trade studies on various alternatives under consideration, including self-healing anti-tank (AT) minefield concepts, advanced tags with minimally guided munitions, and sophisticated spoofing techniques.

• Rapid Combat Insertion (RCI). ($6.0M)
- Compete initial testing of material insertion system components.
- Begin concept development for personnel insertion systems.

(U) FY 2001 Program:

• Glass Turret (GT). ($6.7M)
- Demonstrate integrated radar and electro-optic sensors.
- Complete simulation based design of human interface.

• Advanced Fire Support System (AFSS). ($12.0M)
- Complete system hardware and software development.
- Complete limited objective flight tests.
- Plan and initiate preparations for full system demonstrations.

• Alternatives to Antipersonnel Landmines. ($22.0M)
- Continue technology development for alternatives to antipersonnel landmines.
- Begin basic proof-of-concept testing at laboratory or bread-board level.
- Demonstrate initial self-healing AT minefield communication and movement capabilities.
- Demonstrate appropriate tag wake-up and transmit functions for munition guidance.
- Demonstrate near real-time advanced camouflage techniques for limited conditions and space requirements.
- Develop multi-element real-time image insertion capabilities.

• Rapid Combat Insertion (RCI). ($6.0M)
- Complete development of material insertion system.
- Begin development of man-compatible insertion system.

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APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 2 Applied Research	R-1 ITEM NOMENCLATURE: Tactical Technology, PE 0602702E, Project TT-04

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	20.8	35.0	38.9	46.7
Appropriated	20.6	N/A	N/A	N/A
Current Budget	20.8	35.0	45.8	46.7

(U) **Change Summary Explanation**:

FY 1998 Increase reflects minor repricing.
FY 2000 Increase reflects addition of Glass Turret and Alternatives to Antipersonnel Landmines programs and rephasing of Advanced Fire Support Systems program.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

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APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 2 Applied Research	R-1 ITEM NOMENCLATURE: Tactical Technology, PE 0602702E

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Tactical Technology TT-06	55,091	71,534	57,767	55,728	61,800	68,728	68,728	68,728	Continuing	Continuing

(U) **Mission Description:** This project focuses on seven broad technology areas: (a) compact, efficient, frequency-agile, diode-pumped, solid-state lasers for infrared countermeasures, laser radar, sensors, and high-power applications; (b) compact high density holographic data storage for high bandwidth image processing and access to large data bases; (c) high performance computational algorithms for signal processing, target recognition and tracking, electromagnetic propagation, and processing of advanced materials and microelectronics; (d) precision optics components for critical DoD applications; (e) miniature air-launched decoy systems; (f) an affordable rapid response missile demonstration; and (g) adaptive reasoning and control.

(U) Adaptive reasoning and control is a new start for FY 2000. This effort is a broad technology program to explore, understand and develop truly autonomous reasoning and control systems that utilize input from multiple sensors, perform intensive computations, and respond adaptively to dynamic, uncertain environments. Examples include (a) adaptive, tactical reasoning systems capable of managing uncertainty and executing strategic behaviors in a dynamic environment, (b) tactical systems consisting of large groups of ground robots or micro air vehicles with a shared mission objective, and capable of rapidly evolving self-organized tactical behaviors, and (c) adaptive control systems like lidar-based flow field sensors and controls for aircraft turbulence mitigation, airport wake turbulence detection and avoidance, and autonomous (ship-board) landing systems.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Compact Lasers. ($2.3M)
  - Demonstrated compact high power tunable lasers and laser diodes at mid-infrared wavelengths.
  - Developed breadboard tunable mid-infrared lasers for closed-loop infrared countermeasures.
- Holographic Data Storage. ($2.2M)
  - Demonstrated 1 terabit storage capacity for functional evaluation of holographic data storage systems.
- High Performance Algorithm Development. ($11.8M)
  - Implemented a hybrid automatic target recognition strategy for synthetic aperture radar exploiting most advantageous features of wavelets and nonlinear partial differential equation-based methods.
  - Developed application-specific wavelet-based automatic target recognition algorithms.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology, PE 0602702E, Project TT-06

- Continued development of most promising strategies for data, sensor, and algorithm fusion that exploit the feature extraction capability of wavelets and apply to signal and image processing.
- Developed prototype electromagnetic scattering models for objects in ground clutter.
- Demonstrated toolboxes for generating optimal portable Fast Fourier Transforms and wavelet algorithms and applied to high dimensional synthetic aperture radar.
- Developed mathematical approaches to creating optimal portable applications libraries for selected computational kernels required in thin film process simulations and signal processing applications.

• Advanced Mathematics for Microstructural Process Control. ($6.2M)
- Developed physicochemical models for thin film vapor deposition processes that integrate process, sensing, and control considerations and provide understanding of critical microstructure issues needed to design high-quality and high yield manufacturing processes.
- Implemented fast algorithms for modeling and design of large-scale, high-performance circuits.
- Developed reduced order physicochemical models and algorithms for real-time sensing and control of thin film vapor deposition processes.

• Precision Optics Technology. ($5.4M)
- Continued development of conformal optical system components for tactical systems.
- Completed designs of conformal optics sensor systems and down selected demonstration candidate from airborne platforms or missiles.
- Fabricated aspheric optical components and diffractive optical elements on curved substrates.
- Demonstrated metrology tools.

• Miniature Air-Launched Decoy (MALD). ($18.4M)
- Fabricated and delivered flight test vehicles.
- Conducted flight readiness review.
- Continued ground testing and initiated Development Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) flight testing.
- Began ground and flight maintenance training and began operational training.
- Initiated Seek Eagle process.

• Affordable Rapid Response Missile Demonstrator (ARRMD). ($6.0M)
- Conducted missile concept development, including manufacturing process definition, propulsion integrated flowpath demonstration and manufacturability demonstration.
- Defined flight test plan.
- Began affordability assessment.
- Performed mission assessment.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology, PE 0602702E, Project TT-06

- Facial Recognition. ($2.8M)
  - A program to enable rapid identification of individuals in crowds, subsequently transferred to SOLIC.

(U) FY 1999 Program:

- Compact Lasers. ($6.8M)
  - Demonstrate room temperature long wavelength laser diodes in the 7-to-9 micrometer wavelength range.
  - Complete demonstration of compact high power tunable lasers and laser diodes at mid-infrared wavelengths.
  - Develop packaged tunable mid-infrared lasers for airborne infrared countermeasures.
  - Complete demonstration of laser diode arrays operating at mid-infrared wavelengths.
- Holographic Data Storage. ($1.7M)
  - Complete program with demonstration of holographic data storage for automatic target recognition and data warehousing applications.
- High Performance Algorithm Development. ($17.4M)
  - Demonstrate hybrid automatic target recognition strategy for synthetic aperture radar exploiting most advantageous features of wavelets and nonlinear partial differential equation-based methods.
  - Demonstrate application-specific wavelet-based automatic target recognition algorithms.
  - Validate prototype electromagnetic scattering models for objects in ground clutter.
  - Demonstrate data, sensor, and algorithm fusion algorithms for signal and image processing applications that exploit the feature extraction capability of wavelets.
  - Demonstrate fast algorithms for electromagnetic scattering at subwavelength scales and off rough surfaces.
  - Develop prototype toolboxes and compilation strategies for optimizing key computational kernels in Fast Fourier Transform algorithms.
  - Develop algorithms for designing variable-precision filter for adaptive signal processing.
  - Demonstrate feasibility of mathematical approaches to creating optimal portable applications libraries for selected computational kernels required in complex physical process simulations.
- Advanced Mathematics for Microstructural Process Control. ($11.2M)
  - Develop morphological surface models for deposition of giant magnetoresistive (GMR) films.
  - Develop algorithms for fundamental chemical calculations that allow treatment of larger systems and more extended phenomena in thin film deposition.
  - Develop multiresolution homogenization techniques to reduce systems of partial differential equations to equations amenable to process optimization and design of control algorithms.
  - Validate island dynamics mathematical model and level set methods for epitaxial growth.
  - Validate prototype reactor design for deposition of high temperature superconducting thin films.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology, PE 0602702E, Project TT-06

- Precision Optics Technology. ($6.9M)
  - Continue development of conformal optical system components.
  - Demonstrate near net-shape growth of conformal windows.
  - Laboratory assembly, demonstration and test of conformal sensor system for missile applications.
- Miniature Air-Launched Decoy (MALD). ($17.0M)
  - Continue operational demonstrations, acquire limited flight clearance (Seek Eagle), deliver 32 operational capable test assets, and transition to Services.
  - Explore other concepts of low cost Miniature Air-Launched Decoy (MALD) airframes to fill mission areas such as reconnaissance, surveillance, nuclear/biological/chemical (NBC) detection, jamming, etc.
- Affordable Rapid Response Missile Demonstrator (ARRMD). ($10.5M)
  - Complete propulsion integrated flowpath demonstration and manufacturability demonstration.
  - Perform unit cost analysis.
  - Conduct Warfighting Analysis Lab exercises.

(U) FY 2000 Program:

- Compact Lasers. ($5.7M)
  - Demonstrate mid and long wavelength infrared high power quantum cascade laser diode arrays operating at room temperature.
  - Develop side pump geometries for coupling diode laser arrays to fiber gain medium.
- Precision Optics. ($7.7M)
  - Flight test conformal optics Stinger missile dome to quantify performance improvements.
- High Performance Algorithm Development. ($20.0M)
  - Demonstrate feasibility of optimized portable application library generation approaches for key kernels used for signal processing.
  - Demonstrate utility of multiscale segmentation and registration algorithms in DoD automatic target recognition applications.
  - Develop high fidelity feature extraction algorithms for X-band high range resolution radar based on computational electromagnetic modelling.
  - Develop advanced mathematical algorithms for high throughput hyperspectral infrared imaging.
  - Develop architecture design strategy and portable libraries for implementing variable precision filters in configurable devices.
  - Validate fast algorithms for electromagnetic scattering at subwavelength scales and off rough surfaces.
  - Develop codes for predicting antenna radiation patterns and scattering off of electrically large, smooth impenetrable bodies.

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- Advanced Mathematics for Microstructural Process Control. ($12.4M)
  - Validate morphological surface models for deposition of giant magnetoresistive (GMR) films.
  - Develop models of effects of using surfactants during deposition on interfaces and the GMR ratio.
  - Demonstrate enhanced molecular dynamics/accelerated molecular dynamics simulation techniques for GMR materials.
  - Construct and test control/optimization codes for the sputtering/molecular beam epitaxy reactors.
  - Validate fast first-principles chemical codes.
  - Apply the island dynamics model to films of many monolayers.
  - Extend level set methodology to complex diffusion processes in thin film processing.
- Adaptive Reasoning and Control. ($12.0M)
  - Develop models for dynamic simulation of groups of autonomous systems (micro air vehicles and/or ground robots); develop rule generation strategies, conduct simulations of rule-based, emergent tactical behaviors.
  - Develop expert-in-the-loop laboratory for tactical learning systems and explore learning effectiveness for several hierarchical system architectures in the presence of environmental uncertainties.
  - Perform detailed aircraft dynamic modeling, design turbulence mitigation control system, develop man-in-the-loop cockpit simulator, and conduct aircraft carrier environment measurements.

(U) FY 2001 Program:

- Compact High Peak-Power Lasers. ($6.3M)
  - Develop components for high peak power lasers -- fiber laser oscillator, pulse stretcher, amplifier, and compressor.
  - Demonstrate 1 terawatt peak power laser.
  - Develop core and cladding designs for single mode operation of high power fiber lasers for output power levels of 300 watts.
- Precision Optics. ($6.7M)
  - Flight test conformal optics sensor system on airborne platforms to quantify performance improvements.
- High Performance Algorithm Development. ($16.2M)
  - Demonstrate feasibility and portability of optimized portable application library generation approaches for a complete signal processing algorithm.
  - Investigate techniques for reducing required precision and computational cost of variable precision filter coefficients in configurable hardware implementation.
  - Demonstrate benefits of variable precision filters on an adaptive computing platform.

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- Develop tool set implementing algorithmic, memory, and compilation models applied to a multipole test problem.
- Demonstrate performance and portability of algorithms and application library generation approaches for selected computational kernels required in complex physical process simulations.
- Develop algorithms for predicting antenna radiation patterns and scattering off of electrically large, smooth bodies on problems having realistic geometries.
- Develop fast, high order accurate algorithms for electromagnetic scattering off and through inhomogeneous materials and in deep cavities.

• Advanced Mathematics for Microstructural Process Control. ($8.5M)
- Validate theoretical study of effects of using surfactants during deposition to improve interfaces and the giant magnetoresistive (GMR) ratio.
- Demonstrate reduced kinetic/continuum models for describing the gas phase dynamics and the beam dynamics in a GMR reactor.
- Validate reduced order models and algorithms for sensing and control of thin film vapor deposition processes.
- Validate molecular dynamics/accelerated molecular dynamics simulations of multilayers against experimental results.

• Adaptive Reasoning and Control. ($18.0M)
- Develop demonstration platform and operational scenario for an adaptive tactical reasoning system.
- Integrate mission-driven rule sets into command and control structure for groups of autonomous vehicles (micro air vehicles and/or ground robots) and conduct field tests of autonomous behaviors.
- Build testbed aircraft system for turbulence mitigation and conduct ground based system airport environment measurements.

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	55.1	71.5	79.5	72.7
Appropriated	54.8	N/A	N/A	N/A
Current Budget	55.1	71.5	57.8	55.7

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology, PE 0602702E, Project TT-06

(U) **Change Summary Explanation**:

FY 1998 Increase due to minor repricing. Facial Recognition program was transferred to SOLIC.
FY 2000-01 Decreases reflect completion of the Miniature Air Launched decoy and the Affordable Rapid Response Missile program.

(U) **Other Program Funding Summary Cost**:

	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	Cost to Complete	Total Cost
Funding for Miniature Air-Launched Decoy PE 0603750D, Advanced Concept Technology Demonstrations	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	361.1

(U) **Schedule Profile**: N/A

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology, PE 0602702E					
COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Aeronautics Technology TT-07	20,235	34,000	41,000	59,011	55,000	55,648	55,648	55,648	Continuing	Continuing

(U) **Mission Description:** Aeronautics Technology efforts will address high payoff opportunities to dramatically reduce costs associated with advanced aeronautical systems or provide revolutionary new system capabilities for satisfying current and projected military mission requirements.

(U) A new family of Micro-Air Vehicles (MAVs) that are at least an order of magnitude smaller than current flying systems (less than 15 cm in any dimension) will be developed and demonstrated. The capability to accomplish unique military missions as diverse as covert imaging in constrained areas, biological-chemical agent detection and characterization, remote precision mines, and urban battlefield communications enhancement, will be stressed through an examination of a variety of vehicle concepts. The resulting capability should be especially beneficial in the emerging urban warfighting environment, characterized by its complex topologies, confined spaces and areas (often internal to buildings), and high civilian concentrations. The MAV program will focus on the technologies and components required to enable flight at these small scales, including flight control, propulsion and lightweight power, navigation and communications. These will build upon and exploit numerous DARPA technology development efforts, including advanced communications and information systems, high performance computer technology, Microelectro-mechanical Systems (MEMS), advanced sensors, lightweight, efficient high density power sources, and advanced electronic packaging technologies.

(U) Micro Adaptive Flow Control (MAFC) technologies enable control of large scale aerodynamic flows using small scale actuators. MAFC technologies combine adaptive control strategies with advanced actuator concepts like micro-scale synthetic jets, MEMS-based microactuators, pulsed-blowing and smart structures to cause the delay or prevention of fluid flow separation. This enables potential revolutionary performance capabilities such as low-power, adaptive flight controls for Micro Air Vehicles. MAFC technologies may also apply to larger systems such as adaptive lift-on-demand for agile missiles and uninhabited tactical aircraft, and low-drag, non-intrusive methods to aerodynamically steer projectiles for extended range and precision. Advanced flow control concepts will be explored in the context of system level performance benefits and cost assessments. MAFC technology evaluations will be made under system-relevant flow conditions, and the most promising approaches will be selected for component- or system-level demonstration.

(U) The Navy and the Marine Corps have a need for an affordable, survivable, vertical take-off and landing (VTOL) unmanned air vehicle (UAV) to support dispersed units in littoral and urban areas. The Defense Advanced Research

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
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Projects Agency (DARPA), in partnership with the Office of Naval Research (ONR) and industry, have formulated a program to explore two innovative new vertical take-off and landing (VTOL) concepts with the potential for significant performance improvements that would satisfy stressing mission needs. The first concept is an advanced Canard Rotor/Wing (CRW) concept which offers the potential for a high speed (350 knots), rapid response capability from a VTOL unmanned air vehicle (UAV) with significant range (500 nm) and stealth improvements as compared to other VTOL concepts. Detailed design, fabrication and flight test of this scaled vehicle concept will be conducted to validate the command and control and propulsion system required for vertical take-off, landing and hover via a rotating center wing which is stopped and locked in place for efficient high speed cruise. The second concept (A160), will exploit a hingeless, rigid, in-plain rotor concept to produce a VTOL UAV with very low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. This unique concept offers the potential for significant increases in VTOL UAV range (>500 mn) and endurance (>40 hours). Detailed design, fabrication and testing of this concept will be conducted to establish its reliability, maintainability and performance.

(U) A new, small-scale class of propulsion systems will be developed in the size range from 0.5 cm to 5.0 cm in diameter, with thrust levels from 10 g to 5.0 kg. They will enable future development of a new generation of very small weapons and military platforms including micro air vehicles, UCAVs, missiles and space launch vehicles. Radical new capabilities to be explored range from shirt-button-sized micro gas-turbine and micro rocket engines to 5 cm scale gas-turbine and pulse detonation engines (PDEs). Examples of new mission capabilities include delivery of micro satellites to low earth orbit (LEO) using 2 kg launch vehicles with 70 g payloads, and light weight, affordable, extended range gas-turbine or PDE powered small scale precision munitions. These small scale munitions would complement emerging unmanned vehicle systems and greatly increase mission capabilities by simultaneously increasing loadout, range and precision.

(U) **Program Accomplishments and Plans**:

(U) FY 1998 Accomplishments:

- Micro Air Vehicles ($14.7M)
  - Conducted design and development of functionally diverse propelled MAV systems, employing alternative technology solutions, and satisfying user-identified critical military applications. Explored and demonstrated feasibility of key flight enabling technology component and subsystems. Continued evaluation of operational MAV concepts.
  - Conducted studies of Micro Adaptive Flow Control (MAFC) technology feasibility in the context of selected system applications, including micro air vehicle flight controls and small scale aerodynamically

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steerable munitions. Initiated assessment of actuator effectiveness, scaling, and fabrication methodologies.

- Initiated system design, component tests, and flight control simulations for the Canard Rotor Wing and A160 vertical take-off and landing (VTOL) unmanned air vehicle (UAV) concepts. ($5.5M)

(U) FY 1999 Program:

- Conduct Micro Air Vehicle (MAV) system development and fabrication. Continue exploration and demonstration of flight enabling technologies and subsystems. Initiate flight test planning for propelled systems incorporating operational templates, design flight capabilities, and mission characteristics. Initiate advanced MAV concept definition. ($13.0M)
- Continue studies of Micro Adaptive Flow Control (MAFC) feasibility for micro air vehicles. Explore MAFC applicability to larger scale flows. Initiate exploration and demonstration of MAFC actuator and controller technologies for system-relevant flow conditions. ($7.0M)
- Complete detailed designs, analyses, simulations and component tests and begin fabrication of Canard Rotor Wing and A160 demonstrator aircraft. Conduct engineering, endurance and ground tests. Begin fabrication of two Canard Rotor/Wing (CRW) demonstrators and three A160 demonstrators. ($14.0M)

(U) FY 2000 Program:

- Complete development of flight enabling technologies for micro air vehicles. Complete flight demonstration of the hovering MAV system; complete Build II testing and complete fabrication and flight test of Build III of the fixed wing MAV system; continue concept of operations evaluation for military use. Begin design of advanced MAV flight demonstrator. ($10.0M)
- Continue MAFC actuator and controller development and integrate into feasibility demonstration systems for selected military applications. Build Brassboard demonstrator of high gain adaptive flow demonstrator. ($17.0M)
- Select several candidate small scale propulsion system technologies for detailed design. Begin fabrication of propulsor technology. ($14.0M)

(U) FY 2001 Program:

- Complete advanced MAV development including system fabrication and testing; complete military concept of operations evaluation and complete transition of MAV systems to services. ($10.0M)
- Complete MAFC technology development and validation tests. Integrate MAFC technologies into engine, munition and aircraft systems. Initiate demonstration plan, including flight and field tests of integrated MAFC systems. ($24.0M)

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- Design and fabricate necessary small scale propulsion subsystems and fabricate integrated flight-ready propulsion system prototypes. Conduct subsystem checkout and initial flight test demonstrations. ($25.0M)

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	20.2	34.0	36.0	59.0
Appropriated	16.2	N/A	N/A	N/A
Current Budget	20.2	34.0	41.0	59.0

(U) **Change Summary Explanation**:

FY 1998 Increase reflects repricing to expand the MAFC component of the MAV program.
FY 2000 Increase reflects repricing of the MAFC and MAV programs; and the addition of the Small Scale Propulsion Systems program.

(U) **Other Program Funding Summary Cost**:

FY 1998 $6.0M Defense Airborne Reconnaissance Office (DARO) funding provided for CRW concept demonstration.

(U) **Schedule Profile**: N/A

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COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Logistics Technology TT-10	21,214	21,665	10,633	10,000	20,000	20,000	20,000	20,000	Continuing	Continuing

(U) **Mission Description:** The Advanced Logistics Project will investigate and demonstrate technologies that will make a fundamental difference in transportation and logistics. The program will define, develop, and demonstrate fundamental enabling technologies that will permit forces and sustainment material to be deployed, tracked, refurbished, sustained, and redeployed more effectively and efficiently than ever before. Currently, this is accomplished using isolated, independent, and sometimes incompatible systems, processes and data. Therefore, the very rapid replanning and redirection necessary to support missions involving simultaneous local and major regional conflicts cannot be accomplished today. The Advanced Logistics Project will address these shortcomings and enable this significant capability to be developed. In addition, the project has enormous potential for cost savings through greatly improved management of transportation and logistics assets.

(U) This project will develop automated, multi-echelon, collaborative logistical/transportation technologies that will provide warfighters with an unprecedented capability to monitor, rapidly replan, and execute the revised logistics plan as the situation requires, even while assets are enroute to the theater. The Advanced Logistics Project will focus on the following three areas: 1) Development of applications providing a technology environment that allows warfighters to rapidly understand and assess the logistics and transportation implications of a crisis situation, to generate effective plans and courses of action, to monitor a plan's execution and to use that information to re-plan; 2) Automated systems that will enable significant efficiency improvements in transportation and logistics, such as improving access to data, monitoring the condition and status of shipments, personnel, inventories, logistics assets and the infrastructure, the creation of "plan sentinels" to serve as an early warning system for plan deviations, and improved theater distribution; and 3) Development of a computer network infrastructure that allows distributed real-time visualization and interaction with all phases, elements and components of the military and commercial transportation infrastructure. The capabilities from these three areas will be integrated to demonstrate an end-to-end system solution.

(U) The Advanced Logistics Project supports joint initiatives with the Defense Logistics Agency and is coordinated with other related logistics efforts within the DoD. As these technologies mature, they will immediately transition to other joint initiatives which include: the Defense Logistics Agency Logistics Research and Development (PE 0603712S), the Joint Logistics Advanced Concept Technology Demonstration (Project TT-11), and eventually to the Global Command and Control System (GCCS) and the Global Combat Support System (GCSS).

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(U) **Program Accomplishments and Plans**:

(U) FY 1998 Accomplishments:

- Demonstrated an integrated computer environment to support automated planning, execution and monitoring of a major force deployment from fort to port to ship load, including optimized scheduling and routing with minimal staging throughout the move. ($8.0M)
- Initiated development of plan deviation detection sentinels and predictive analysis to assist in identification of replanning opportunities. ($3.5M)
- Continued development of advanced software data collection techniques. Initiated development of a Dynamic Critical Items List for sustainment planning and execution. Continued development of multi-echelon collaborative logistical support technologies. Developed and demonstrated an initial automated coarse-grained course of action evaluation that is linked to the war plan. ($9.7M).

(U) FY 1999 Program:

- Demonstrate an integrated environment to support the planning, execution and monitoring of a unit deployment from point of debarkation through in-theater distribution, including automated infrastructure assessment and monitoring. ($9.2M).
- Develop and demonstrate the ability to negotiate the exchange of information between suppliers and buyers, including rapid, flexible item and item relationship catalogs for automated sustainment processing. ($5.0M)
- Develop automated deviation detection and triggering of the replanning processes. Continue development of a Dynamic Critical Items List for sustainment planning and execution. Develop and demonstrate automated medium grained course of action evaluation that is linked to the war plan. ($7.5M).

(U) FY 2000 Program:

- Develop capability to automatically plan and schedule movements from installation to the theater of operations and integrate the resulting movement plan with operations within the theater. Demonstrate capability for users to visualize multiple facts of the transportation schedule. ($2.7M)
- Develop capability to dynamically manage stockage levels across multiple supply chain levels and, multiple echelons, services and agencies. ($3.4M)
- Develop capability to automatically notify users when projected completion of an executing task differs from planned timeline. ($4.5M)

(U) FY 2001 Program:

- Develop capability to automatically build and compare logistics plans in support of four operational courses of action in 4 hours. ($6.4M)

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- Develop capability to monitor resource information, availability, capacity, costs and to view past, present and projected logistical situations. ($3.6M)

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	21.2	21.7	10.6	10.0
Appropriated	23.2	N/A	N/A	N/A
Current Budget	21.2	21.7	10.6	10.0

(U) **Change Summary Explanation:**

FY 1998 Decrease reflects minor rescoping of efforts.
FY 1999 Decrease reflects minor repricing.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology, PE 0602702E					
COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Joint Logistics ACTD TT-11	10,191	10,000	10,000	10,000	10,000	0	0	0	0	N/A

(U) **Mission Description:** The Joint Logistics ACTD is a multi-phase program which will provide an experimental environment where logisticians can evaluate maturing tools and technologies for increased operational capability. Initial efforts will integrate existing tools that exploit near real-time logistics data sources operating within the Global Combat Support System (GCSS). Key data sources include Joint Total Asset Visibility (JTAV), Joint Personnel Asset Visibility (JPAV), and Global Transportation Network (GTN), Joint Operational Planning and Execution System (JOPES) and the Global Status of Readiness and Training System (GSORTS). This program will also provide a migration path for evaluating advanced technologies that are being developed by other programs such as the DARPA Advanced Logistics Technology Project (TT-10). Focus areas for the Joint Logistics ACTD correspond to Commander-in-Chief (CINC) and Service requirements to develop Joint Decision Support Tools (JDST) capability in the areas of Force Capability Assessment; Course of Action Generation; Distribution, Materiel Management, and Maintenance Analysis; and Visualization. Inherent in these requirements are the capabilities to compare planned to actual performance, to detect deviation from expected values, and to modify logistics activities as the result of analysis. The ACTD will support CINC/Joint Task Force (JTF) and Service/Agency logisticians across the entire operational spectrum -- mobilization, deployment, employment, sustainment and redeployment.

(U) **Program Accomplishments and Plan:**

(U) FY 1998 Accomplishments:

- Defined operational architecture and network requirements for employment of joint decision support tools for CINCs, Components, and Services that operate within the GCSS environment and exploit near real-time data feeds (JTAV, JPAV, GTN, etc.) into a common operating picture between operations and logistics. ($3.1M)
- Designed, developed, and demonstrated an initial set of web-based joint decision support tools. ($5.7M)
- Finalized plans to demonstrate access to JDSTs within GCSS environment in a joint warfighting exercise. ($1.4M)

(U) FY 1999 Program:

- Develop data access and mediation capability to pull information from mediated data sources and to share data and JDST data products between applications through a common user interface. ($3.0M)
- Expand tool set functionality focusing on Component and Service needs. Transition proven tools through the DARPA/Defense Information Systems Agency (DISA) Joint Program Office (JPO) into GCSS. ($5.5M)

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- Develop and demonstrate the capabilities to provide a qualitative force capability assessment and generate a logistics support force structure for CINC/JTF use. ($1.5M)

(U) FY 2000 Program:

- Expand development of Joint Decision Support Tools (JDST) into initial Focused Logistics by fusing logistics and operations applications in the Global Command and Control System (GCCS) and GCSS. ($5.0M)
- Expand JDST to integrate in-theater distribution support planning and automated infrastructure assessment and monitoring ($2.0M)
- Incorporate and enhance planned deviation detection technology and sentinels into Focused Logistics support tools. ($2.0M)
- Develop and demonstrate the capabilities to access commercial and direct vendor data sources, and to interface with Automatic Identification Technology System (AITS) products. ($1.0M)

(U) FY 2001 Program:

- Develop capability to calculate support unit requirements and sustainment and identify matching sources to meet mission requirements. ($5.0M)
- Develop capability to rapidly assess the impact of operational changes upon the logistics support structure. ($3.5M)
- Demonstrate multi-echelon interoperability in a joint warfighting exercise. ($1.5M)

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	10.2	10.0	10.0	10.0
Appropriated	10.2	N/A	N/A	N/A
Current Budget	10.2	10.0	10.0	10.0

(U) **Change Summary Explanation**: N/A

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research				R-1 ITEM NOMENCLATURE Integrated Command and Control Technology, PE 0602708E, R-1 #16						
COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
High Definition Systems IC-03	45,695	34,000	32,000	32,000	0	0	0	0	0	N/A

(U) **Mission Description:** This program element is budgeted in the Applied Research Budget Activity because it develops the technologies for high definition displays that are important for virtually all DoD applications that involve visual and graphic information. Major components of this program include: projection, head mounted and direct view displays based on multiple technologies; development of equipment and components required to manufacture advanced display technologies; and prototyping of display systems for system evaluation. These efforts will establish a domestic technical capability for the manufacture of components necessary for military systems that capture, process, store, distribute and display high resolution images.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Continued development of large organic-based display technologies and systems for command and control applications, including laser based projection. ($9.3M)
- Continued development of equipment and components to meet display cost and performance goals. This included efforts in printing and microreplication, field emission display materials, organic light emitting materials, phosphor technology development, and support for the domestic display manufacturing infrastructure. ($25.1M)
- Completed High Definition Optoelectric Digital Camera development. ($2.0M)
- Initiated Display Glass Manufacturing development. ($3.8M)
- Continued development of system prototypes which leveraged earlier developed display technologies, particularly for mobile displays and incorporated integrated systems and intelligent interfaces. ($5.5M)

(U) FY 1999 Program:

- Complete development of large organic-based display technologies and continue development of displays for command and control applications. ($10.0M)
- Continue development of equipment and components to meet display cost and performance goals. This will include efforts in printing and microreplication, field emission display materials, organic light emitting materials, and phosphor technology development. ($12.0M)

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- Complete first generation integrated display systems and system prototypes for mobile applications. Continue development of large screen command and control system prototypes. ($12.0M)

(U) FY 2000 Program:

- Develop flexible, rugged displays based on organic electroluminescence and zero-power reflective technology. ($9.0M)
- Develop active matrix backplanes on flexible substrates for high performance/low power rugged displays. ($8.0M)
- Develop enhanced maturing technologies (color inorganic electroluminescence, field emission, high brightness head mounted displays, etc.) to performance capabilities required for DoD applications. ($6.0M)
- Develop roll-to-roll processing for inexpensive, flexible, rugged, displays for DoD applications. ($5.0M)
- Demonstrate/insert display technology into DoD systems to evaluate display technology. ($4.0M)

(U) FY 2001 Program:

- Demonstrate full color reflective and emissive displays on flexible substrates for reduced weight and improved ruggedness. ($9.0M)
- Integrate organic light emitting diodes on flexible, active matrix backplanes for increased brightness and reduced power. ($7.0M)
- Determine scalability of roll-to-roll processing for large, high-resolution emissive displays. ($6.0M)
- Evaluate new display concepts for large, high-resolution displays. ($5.0M)
- Demonstrate/insert display technology into DoD systems for display evaluation. ($5.0M)

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	45.7	34.0	32.0	32.0
Appropriated	47.2	N/A	N/A	N/A
Current Budget	45.7	34.0	32.0	32.0

(U) **Change Summary Explanation**:

FY 1998 Decrease reflects realignment of program priorities.

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(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

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APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 2 Applied Research	R-1 ITEM NOMENCLATURE: Materials and Electronics Technology, PE 0602712E, R-1 #17

COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Materials and Electronics Technology	**231,353**	**244,408**	**255,134**	**287,208**	**274,706**	**266,640**	**281,640**	**301,640**	**Continuing**	**Continuing**
Materials Processing Technology MPT-01	122,081	145,381	156,066	196,327	190,280	170,227	175,227	185,227	Continuing	Continuing
Microelectronic Device Technologies MPT-02	74,520	87,910	87,522	78,881	69,426	80,413	90,413	100,413	Continuing	Continuing
Cryogenic Electronics MPT-06	18,404	8,203	11,546	12,000	15,000	16,000	16,000	16,000	Continuing	Continuing
Military Medical/Trauma Care Technology MPT-07	16,348	2,914	0	0	0	0	0	0	0	N/A

(U) **Mission Description**: This program element is budgeted in the Applied Research Budget Activity because its objective is to develop technology related to those materials, electronics, and biological systems that make possible a wide range of new military capabilities.

(U) The Materials Processing Technology project (MPT-01) concentrates on the development of novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components which will lower the cost, increase the performance, and enable new missions for military platforms and systems. Areas of concentration include exploitation of emerging processing approaches to tailor the properties and performance of structural materials and devices. This emphasis includes lightweight personnel protection, mesoscale machines for miniature devices, and ultra lightweight materials. The project also focuses on smart materials, sensors and actuators, functional materials and devices, advanced magnetic materials for non-volatile, radiation hardened magnetic memories, and electroactive polymers for sensing and actuating. Other areas of concentration include new materials concepts for portable power, protective coating materials to eliminate environmental hazards, infrared artificial dielectrics, development of bio-interface materials and methods, energy harvesting concepts, and frequency agile materials based on ferrite and ferroelectric oxides. This project also includes a biological systems thrust. The unique characteristics of biologically derived functional materials and devices will be exploited through the understanding and control of the structure and chemistry of the interface between man-made and biotic materials. In addition, emulation and/or control of biological functionality (i.e., sensing and mobility) will be explored for enhanced DoD sensor, robotic, etc. applications.

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(U) The Microelectronics Device Technologies project (MPT-02) develops advanced electronic and optoelectronic devices, semiconductor process tools and methodologies, materials for optoelectronics and infrared devices. Areas of emphasis include high-performance analog-to-digital converters, military optical processors, novel integrated optoelectronic devices and components, high temperature electronic devices, and high power electronics. This project includes a significant effort to develop advanced materials and device technology beyond the classical scaling limits of silicon device technology.

(U) In the Cryogenic Electronics project (MPT-06), thin film electromagnetic materials have reached a stage of development where specific applications can be identified in electronic devices and circuitry for military applications. Thin-film high temperature superconducting components packaged with cryogenic devices are being applied to radars, electronic warfare suites, and communications systems to enhance performance while reducing size and power requirements. Highly dependable and inexpensive cryocoolers (including thermoelectric coolers) are being developed for these applications, and expanded efforts will explore techniques to improve the performance of all solid state thermoelectric coolers as well as the overall cryogenic performance in applications ranging from communications to computing.

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COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Materials Processing Technology MPT-01	122,081	145,381	156,066	196,327	190,280	170,227	175,227	185,227	Continuing	Continuing

(U) **Mission Description**: The major goals of this project are to develop novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components which will lower the cost, increase the performance and/or enable new missions for military platforms and systems.

(U) One important area of concentration is the exploitation of emerging processing approaches to tailor the properties and performance of structural materials and devices. Thrusts in this area include new concepts for lightweight personnel protection, ultra lightweight materials, and multi-functional materials for lowering the weight and increasing the performance of aircraft and spacecraft structures. Approaches are also being developed for reducing the risk in defense acquisitions of using new materials. Smart materials, sensors and actuators for the control of the aerodynamic and hydrodynamic behavior of military systems are being developed and demonstrated to increase performance and lower detectability of aircraft, helicopters and submarines. Intrinsically smart materials which provide self-diagnosis and/or self-repair will be developed as well.

(U) A second major thrust is the development of functional materials and devices. This includes advanced magnetic materials for high sensitivity, magnetic field sensors; non-volatile, radiation hardened magnetic memories with very high density, short access time, infinite cycleability and low power; and electroactive polymers for sensing, actuating, and analog processing. Frequency-agile materials based on ferrite and ferroelectric oxides are being developed for tuned filters, oscillators and antennas. New permanent magnetic materials with significantly higher magnetic strength and higher operating temperature for motors, generators, flywheels, bearings, and actuators are also being explored. New materials and concepts for increasing the availability of portable power to the soldier are being investigated as are approaches for deriving power for soldiers and sensors from the environment. Infrared Artificial Dielectrics (IRADs) are a new class of infrared materials having an emissivity that can be fully engineered for different spectral bands.

(U) The mesoscopic size range ("sugar cube to fist") offers significant advantages in devices for defense. Efforts include mesopumps for battlefield sensors and mesocoolers for the soldier. Technology for mask-less, direct-write of

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mesoscopic integrated conformal electronics will enable the three-dimensional integration of passive components, significantly reducing the size and cost of integrated electronics functions (batteries, antennae, etc.).

(U) Finally, the unique characteristics of biologically derived functional materials and devices will be exploited through the understanding and control of the structure and chemistry of the interface between man-made and biotic materials. In addition, emulation and/or control of biological functionality (sensing, mobility, etc.) will be explored for enhanced DoD sensor, robotic, etc. applications.

(U) **Program Accomplishments and Plans**:

(U) FY 1998 Accomplishments:

- Structural Materials and Devices. ($29.6M)
  - Demonstrated low cost titanium and superalloy component fabrication processes.
  - Demonstrated uniformly bonded face sheet attachment on ultra lightweight foamed metal structures.
  - Demonstrated a 5x reduction in prototyping time (print-to-part) for ceramic and metal gas turbine engine components utilizing solid freeform manufacturing.
  - Demonstrated a laser workcell at a beta test site.
  - Established approaches for breakthrough gains in personnel protection performance (e.g., >100 percent improvement from current capabilities for 7.62 mm armor piercing round) through the application of innovative materials, materials processing and phenomenological modeling of multicomponent materials systems.
  - Built a high precision, silicon nitride roll gimbal and pitch shaft for an infrared seeker utilizing Shaped Deposition Manufacturing, which combines additive and subtractive processing.
  - Initiated mesoscale machine demonstrations of interest to the DoD including a miniature air pump and a micro-cooler.
  - Evaluated an Al-Be F-15 rudder spar.
  - Evaluated structurally porous, ultra-lightweight aircraft panels.
  - Completed the fabrication and evaluation of nanostructured, hard carbon coatings with high adhesion, low friction, high hardness and high wear resistance.
- Smart Materials and Actuators. ($24.7M)
  - Demonstrated a fabrication process for microintegrated smart materials.
  - Demonstrated full size, smart material active helicopter blade structures and acoustic noise suppression structure on a rotor test stand.

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- Evaluated actuation potential of magnetoelastic and magneto-shape memory transducer materials.
- Evaluated high performance electroceramic actuator fabrication processes.
- Demonstrated applicability of a smart shape adaptive wing to vortex destabilization in hydrodynamic applications.
- Designed, built, tested and evaluated high power laminated actuator stacks for smart defense structures utilizing Computer Aided Manufacturing-Laminated Engineering Materials (CAM-LEM) solid freeform fabrication capability.

• Functional Materials and Devices. ($46.6M)
- Demonstrated a prototype giant magneto-resistive (GMR) magnetic memory array and spin transistor memory cell array using magnetic multilayers.
- Developed microstructural models for prediction of GMR thin film properties.
- Designed and built a very high sensitivity magnetometer.
- Continued polymer development using advanced lithography techniques for infrared artificial dielectrics (IRADs).
- Demonstrated electroactive optical flow characteristics of polymers.
- Initiated effort to reduce loss tangent in ferrites and ferroelectric oxides for frequency agile RF components.
- Demonstrated a switched circulator and phase shifter using thick film ferrites.
- Selected model systems for establishing the structure, chemistry, and function of biotic/abiotic interfaces and biological systems which provide the capability to design biological and biohybrid devices of interest to the DoD (e.g., sensors, smart membranes, actuators, etc.).
- Demonstrated proof of concept for templated vapor phase single crystal growth on projected x-ray interference patterns of atomic dimensions.
- Demonstrated high-density electronic interconnects for Seamless High Off-Chip Connectivity (SHOCC) interposer.

• Energy and Environmental Sciences. ($21.2M)
- Demonstrated a hydrothermal oxidation pilot plant for the destruction of shipboard excess hazardous materials.
- Demonstrated the utility of advanced erosion/corrosion resistant thin film coatings at a military site.
- Demonstrated intelligent processing of thermal barrier coatings yielding reliable coatings which increase turbine engine inlet temperatures by up to 200 degrees F, with a commensurate increase of 10-15% in thrust.

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- Developed balance-of-plant and packaging for a direct oxidation fuel cell replacement for military standard batteries.
- Demonstrated that full scale, intelligent processing of copper-indium diselenide (CIS) solar cells yields both performance and cost (<$1/watt) suitable for use of flexible photovoltaics in military operations.
- Developed energy harvesting and storage concepts for unattended devices.

(U) FY 1999 Program:

- Structural Materials and Devices. ($33.1M)
  - Fabricate and test materials and materials systems concepts designed to significantly improve personnel protection performance (e.g., >100 percent improvement from current capabilities for 7.62 mm armor piercing round), dramatically increasing protection for the individual soldier.
  - Demonstrate solid freeform fabrication of titanium forging blanks.
  - Demonstrate spray forming of superalloy forging billets.
  - Demonstrate the use of solid freeform fabrication to upgrade distressed turbine vanes in man-rated gas turbine engines with ceramic composite components of high reliability.
  - Demonstrate initial feasibility and performance of prototype mesoscale machines (miniature air blower, microcooler, meso pump, etc.).
- Smart Materials and Actuators. ($26.5M)
  - Demonstrate vortex wake reduction for submarines using smart materials.
  - Demonstrate submarine acoustic noise reduction using smart material tiles.
  - Demonstrate a shape adaptive fighter inlet.
  - Establish growth conditions for piezoelectric single crystals from flux using both open and closed crucible techniques.
  - Evaluate the impact of piezoelectric single crystals on Navy low-frequency surveillance sonar, mid-frequency navigation/tactical sonar, and high-frequency weapons guidance sonar.
- Functional Materials and Devices. ($60.6M)
  - Demonstrate high speed, radiation hard, medium density, non-volatile magnetic memory utilizing magnetic multilayers; develop methods for controlling microstructure of giant magneto-resistive (GMR) films during growth.
  - Demonstrate very high sensitivity magnetometer and gradiometer for localization of magnetic anomalies.
  - Demonstrate a permanent magnet material with a 50 percent higher strength (energy product).
  - Expand the use of solid freeform fabrication to demonstrate a new process for the fabrication of silicon carbide devices using rapid tool-less vapor deposition processes.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology, PE 0602712E, Project MPT-01

- Complete polymer development for infrared artificial dielectrics (IRADs).
- Demonstrate actuation capability of polymeric muscles.
- Demonstrate a loss tangent less than 0.002 in hybrid ferrite/ferroelectric frequency agile filters.
- Demonstrate a voltage controlled oscillator (VCO) with an octave tuning range and low loss.
- Demonstrate scale-up capability for single crystal growth utilizing x-ray interference patterns to template crystal growth.
- Demonstrate enhanced biological responses (molecular, cellular and organismal) at modified material interfaces. Identify approaches for the neurological control and behavior of simple biological systems through biomaterial development.
- Demonstrate actuator materials and bioinspired control strategies for biomimetic locomotion systems; develop biomimetic systems that incorporate extremophile strategies for enhanced stability and performance in the environmental extremes required by the DoD.
- Select available functional elements for preliminary experiments and establish system specification for tropomorphic systems, i.e., systems which self-adaptively shed, heal, morph and grow to meet operational requirements.

• Energy and Environmental Sciences. ($25.2M)
- Demonstrate a low temperature, packaged direct oxidation fuel cell for soldier applications.
- Demonstrate alternative energy sources (including thermal energy conversion) for soldier microclimate cooling and for portable battery chargers.
- Demonstrate energy harvesting concepts from ambient sources for unattended sensor applications.
- Demonstrate approaches to augment portable power sources by recovering energy from human activity.
- Complete demonstration and insertion of advanced erosion/corrosion resistant thin film coatings in military systems.

(U) FY 2000 Program:

• Structural Materials and Devices. ($26.0M)
- Integrate material concepts and materials systems into ultra-lightweight armor providing 100 percent improvement in personnel protection for the soldier.
- Identify and evaluate concepts for using multifunctional materials (e.g., combined structural and thermal) to improve the performance and/or lower the cost of defense systems.
- Develop analytical, experimental, and simulation technologies for predicting the cost, performance, and life of advanced materials, decreasing the risk of and accelerating the time for insertion of new materials in defense acquisitions.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology, PE 0602712E, Project MPT-01

- Smart Materials and Actuators. ($25.5M)
  - Demonstrate 20 dB vibration reduction (1/4 scale demo) using active hybrid mounts on equipment racks for ships.
  - Demonstrate improvements in aerodynamic performance through wind tunnel testing of wings with adaptive leading and trailing edge control surfaces.
  - Develop a "smart skin" for the reduction of self noise and radiated noise in torpedoes.
  - Demonstrate polymeric actuators that emulate the mechanical response and performance of human muscles.
  - Demonstrate the performance of single crystal piezoelectrics in broadband ultrasonic imaging transducers.
  - Demonstrate techniques to grow large (>3cm) single crystals of relaxor piezoelectrics.
- Tropomorphic Systems. ($16.5M)
  - Demonstrate functional tropomorphic effectors for target biochemical molecules.
  - Determine the capability for biochemical decontamination of surfaces via secretion/dispersion from micromachined surface orifices.
- Functional Materials and Devices. ($47.7M)
  - Demonstrate very fast (<20 nsec access time) at high density, radiation hard magnetic memory circuits utilizing both giant magneto-resistance multilayers and spin dependent tunneling devices; fully understand the micromagnetics of magnetic domain rotation in these devices.
  - Demonstrate very small, low power, high sensitivity magnetic gradiometers for the localization and identification of small ferrous objects.
  - Demonstrate permanent magnet materials with 75 percent higher magnetic strength (energy product) and the ability to preserve magnetic properties to temperatures over 250 C.
  - Demonstrate a loss tangent less than 0.001 in hybrid ferroelectric/ferrite devices.
  - Demonstrate a broadband 360 degree phase shifter with very low loss for antenna feed applications.
  - Demonstrate green light-emitting diodes (LED) fabricated from electroactive polymers, with a half-life >5,000 hours; demonstrate blue and red LEDs with >1,000 hours half-life.
  - Select appropriate polymers with electronic characteristics for field-effect transistor (FET) development.
  - Demonstrate growth of AlGaSb-InAs thin films on GaAs substrates using the lateral epitaxial overgrowth technique.
  - Demonstrate lattice mismatched epitaxial growth of dislocation free compound semiconductors using strain absorbing layers.
- Advanced Energy Technologies. ($16.1M)
  - Demonstrate and field test compact portable power systems in soldier applications.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology, PE 0602712E, Project MPT-01

- Develop high efficiency direct thermal to electric energy conversion.
- Demonstrate in the laboratory a compact >500 W battery charger operating on logistics fuel.
- Demonstrate in the laboratory power generation from ambient sources capable of operating unattended ground sensors.

• Biomimetic Systems. ($10.5M)
- Construct prototype microelectronic interfaces for control of biological systems.
- Evaluate chemical, visual, and acoustic cues used by biological systems for controlled locomotion, behavior, and distribution.
- Evaluate computational neuromechanics and biomechanics of locomotion and sensormotory control schemes.
- Evaluate training regimens for biological system control.
- Determine sensormotory and navigational control schemes for biological systems through microelectronic interfaces.

• Mesoscopic Structures and Devices. ($13.8M)
- Demonstrate the operation of a mesoscopic pump array with flow rates over 5 liters/min. in one cubic inch.
- Build and test an individual integrated mesoscopic cooler.
- Demonstrate a mesoscopic vacuum pump integrated with a mass spectrometer on a chip.
- Demonstrate the ability to directly write passive electronic materials and components at the mesoscale.
- Demonstrate prototype active materials (ferrites and ferroelectrics) via direct fabrication at the mesoscale.

(U) FY 2001 Program:

• Structural Materials and Devices. ($31.0M)
- Demonstrate ultra-lightweight armor with 100 percent improvement over current capability and begin transition of manufacturing/design capabilities to the Army.
- Demonstrate the use of multifunctional materials to provide an order of magnitude improvement in the capabilities of specific defense systems.
- Continue the optimization of analytical, experimental, and simulation technologies for predicting the properties of advanced materials.
- Select specific material(s) of high value to a DoD system for demonstration of accelerated insertion concepts.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology, PE 0602712E, Project MPT-01

- Smart Materials and Actuators ($34.0M)
  - Complete wind tunnel test verification of an active aircraft engine inlet enabling a 20 percent increase in aircraft mission radius compared to the conventional fixed geometry inlet design.
  - Complete water tunnel test of a subscale submarine propulsor with active control to reduce acoustic radiation levels.
  - Complete flight test for rotorcraft with blades containing integral actuators and flaps for control of noise and vibration.
  - Demonstrate methods to fabricate multilayer actuators made from single crystals of relaxor piezoelectrics.
  - Demonstrate high strain performance (>0.5 percent) of single crystal piezoelectrics in electromechanical actuators.
  - Demonstrate performance of single crystal piezoelectrics in an advanced Navy sonar transducer.
  - Develop intrinsically smart materials that monitor their own state of "health" and repair themselves as required.
- Tropomorphic Systems. ($22.0M)
  - Demonstrate functionality of 3-D devices built in-situ from tropomorphic effectors.
  - Downselect and define performance goals of prototype tropomorphic systems to be demonstrated.
- Functional Materials and Devices. ($52.5M)
  - Demonstrate a prototype radiation hard, very high density (>64 Mbit), high speed (<10 nsec access time) magnetic memory circuit based on giant magneto-resistance or spin-dependent tunneling utilizing very low power and low voltage (<2.5 Volts).
  - Design a prototype slotless integral motor/pump with advanced magnetic materials for improved efficiency and performance.
  - Demonstrate a steerable ferroelectric lens for a phased array radar.
  - Demonstrate a conformal, frequency agile antenna that is 100x smaller than conventional technology.
  - Demonstrate a large area fabrication process for light-emitting diodes (LEDs).
  - Demonstrate electronic mobility of $>10^{-4}$ cm^2/Vs in electroactive polymeric materials or discontinue effort.
  - Demonstrate use of electroactive polymers as thin film spatial filters for quasi-real-time multispectral image analysis for enhancing target detectability.
  - Fabricate preamplifier for a millimeter wave radar front end with a 4 dB improvement in sensitivity using lateral epitaxial overgrowth fabrication capabilities.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology, PE 0602712E, Project MPT-01

  - Demonstrate use of twist bonded substrates for integration of an infrared focal plane with integrated read-out electronics.
  - Develop techniques that use the intrinsic response of a material to its operating environment to provide diagnosis of the performance life of the material.
- Advanced Energy Technologies. ($20.3M)
  - Demonstrate a compact turbo-generator with improved efficiency for portable power and battery charger applications utilizing ceramic components and operating on logistics fuel.
  - Demonstrate energy harvesting from ambient sources for unattended sensor applications.
  - Field test integrated energy harvesting systems in soldier applications.
  - Demonstrate in the laboratory high efficiency direct thermal to electric energy conversion operating on a hydrocarbon fuel.
  - Develop and demonstrate ultra-high energy density power source concepts.
- Biomimetic Systems. ($18.7M)
  - Demonstrate operational fidelity of microelectronic interface control of locomotion, sensormotory navigational guidance, and behavior.
  - Exploit chemical, visual, and acoustic cues for controlling locomotion, behavior, and distribution of biological systems.
  - Evaluate plasticity in training regimens for control of biological systems.
  - Demonstrate biological system control paradigms for operationally relevant scenarios.
  - Demonstrate millimeter to centimeter scale locomotion emulating that of biological systems.
  - Identify candidate advanced sensor systems which incorporate concepts including self-calibration, self-healing, functionally responsive, and mobile.
  - Investigate critical design parameters for advanced biologically based sensor candidates.
- Mesoscopic Structures and Devices. ($17.8M)
  - Demonstrate mesoscopic compressor operation that can work against 4 times atmosphere pressure.
  - Demonstrate a mesh of fully functional integrated mesoscopic coolers that exhibit a coefficient of performance (>4) and have 1/3 the weight of the smallest normal-scale coolers.
  - Demonstrate that direct-write mesoscale active and passive components have functionality equivalent to discrete surface mount components.
  - Demonstrate the rapid integration of direct-write passive components with integrated circuits.
  - Demonstrate the ability to direct-write mesoscale passive components, batteries, and capacitors on complex geometries.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology, PE 0602712E, Project MPT-01

- Fabricate x10 gain patch antenna that has the same footprint as a commercial antenna on a conformal substrate.

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	122.1	145.4	142.0	139.3
Appropriated	106.7	N/A	N/A	N/A
Current Budget	122.1	145.4	156.1	196.3

(U) **Change Summary Explanation**:

FY 1998 Increase reflects expansion of efforts in the Smart Materials and Functional Materials thrusts.
FY 2000-01 Increases reflect expansion of efforts in Tropomorphic Systems, Biomimetic Systems, and Mesoscopic Structures and Devices.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 1998	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research				R-1 ITEM NOMENCLATURE Materials and Electronics Technology, PE 0602712E						
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Microelectronic Device Technologies MPT-02	74,520	87,910	87,522	78,881	69,426	80,413	90,413	100,413	Continuing	Continuing

(U) **Mission Description**: This project develops advanced electronic and optoelectronic devices, semiconductor process tools and methodologies, materials for optoelectronics, and infrared devices. Areas of emphasis include high performance analog-to-digital (A/D) converters, military optical processors, novel integrated optoelectronic devices and components, high temperature electronic devices and high power electronics. This microelectronics development project develops and demonstrates advanced microelectronics technology for DoD critical needs including digital radar receivers and acoustic-electronic components. Technologies developed in this project are performance driven and exceed commercial capabilities. This project includes a significant effort to develop advanced material and device technology beyond the classical scaling limits of silicon device technology.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Advanced Microelectronics - Chose candidate interconnect/stacking strategies. ($2.5M)
- Developed SiC materials for High Power Electronic Power Switching Devices in the 250°- 350°C range. ($2.0M)
- Evaluated thermal management strategies for megawatt-class power switch; evaluated approaches for controlling high-power switches with solid-state electronics (monolithic vs. hybrid); demonstrated 1000-V-class SiC switch. ($4.8M)
- Explored photonic approaches in the throughput of analog-to-digital (A/D) converters. ($3.8M)
- Digital Receiver Processor -·Continued efforts to develop advanced digital-based processor components based on high speed semiconductor technologies, such as heterojunction bipolar transistors. ($12.5M)
- Sonoelectronics - Initiated development of highly-effective sonoelectronic actuators and transducers that can be integrated directly with silicon Very Large Scale Integrated (VLSI) circuits. ($7.7M)
- VLSI Photonics - Demonstrated feasibility of integration of small arrays (4x4) vertical cavity surface emitting lasers with detectors, and identified degradation mechanism for polymer/small molecule lasers and demonstrated photopumped lasing. ($11.5M)
- Low Power Electronics - Developed circuits and circuits level design tools to reduce power dissipation for variety of circuits and assist in circuits level tradeoffs. ($1.0M)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology, PE 0602712E, Project MPT-02

- 3-D Microelectronics - Developed and demonstrated key technologies behind a packaging concept that used a stacked MCM approach to reduce interconnect length and increase physical connectivity between layers of electronics. ($4.8M)
- Microelectronics Activity - Continued technology insertions with the Defense Microelectronics Activity through transfer of this program to the Defense Logistics Agency. ($9.7M)
- Mixed-Mode Electronics - Initiated mixed-mode electronics multitechnology insertion (MIME). ($7.2M)
- Nanofabrication - Investigated areas of nanofabrication of electronic devices and extreme ultraviolet (EUV) lithography to be used in the next decade for the fabrication of semiconductor devices, such as nanoelectronics and micromechanical structures. ($6.0M)
- RF Photonics - Completed research in Radio Frequency Photonics. ($1.0M)

(U) FY 1999 Program:

- Advanced Microelectronics - Characterize candidate 25 nm transistors $(150nm)^2$ total area and establish process sequence for chip for proof-of-principle demonstration. ($10.1M)
- Digital Radar Receiver Processor - Develop advanced digital processor components. ($11.0M)
- Continue development of SiC materials for High Power Electronic Switching Devices. ($2.0M)
- Demonstrate high-current-density (>100 A/cm^2) 1000-V-class SiC high power switch; demonstrate high-temperature (>250 C) operation of a 1000-V-class switch. ($7.0M)
- VLSI Photonics - Demonstrate integrated 8x8 VLSI photonics chip (laser, detector and electronics) and optoelectronic modeling tools compatible with electronic CAD tools and demonstrate the feasibility of using molecular self-assembly techniques to position optoelectronic devices with high precision on silicon circuits. ($20.0M)
- Sonoelectronics - Carry out full sonoelectronic integration, combining surface micromachined transducer arrays, low-noise Complementary Metal Oxide Semiconductor (CMOS) electronic readout, acoustic lens and packaging technology, and low-power display technology to fabricate high resolution underwater imager. Begin designing transducers, arrays, and an integration approach for air-coupled operation. ($16.0M)
- HERETIC - Demonstrate heterostructure integrated thermoelectric (TE) or thermionic devices having the same heat-removal capacity as the best commercial off-the-shelf TE coolers; fabricate micro-jets, micro-nozzles or micro-thermionic emitters capable of monolithic integration with Si circuits. ($5.0M)
- Begin development of integrated fluidic cooling systems having 1/100 the volume and mass of current state-of-the-art systems. ($4.8M)
- Initiate fiber coupled IR sensor development for expanded sensor performance. ($3.0M)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology, PE 0602712E, Project MPT-02

- Initiate silicon RF program. Demonstrate microswitches with very low insertions loss, high isolation, and low actuation voltage. Develop fabrication processes for embedded RF microcomponents on large area substrates. ($9.0M)

(U) FY 2000 Program:

- Silicon RF program - Demonstrate capability to produce large arrays of microswitches. Begin development of integration technologies for switch layers with signal distribution layers. ($21.0M)
- Digital Receiver Technology Program - Demonstrate a very high performance analog-to-digital (A/D) converter with 14 effective bits, 60 MHz instantaneous bandwidth, and >86 dB spurious free dynamic range (SFDR) in FY00 with potential for multiple military applications. ($2.0M)
- High-Powered Solid State Electronics - Demonstrate high-current density (>100 A/cm^2) 2500-V class switch from SiC; demonstrate 2500-V rectifier diode from GaN. ($3.0M)
- Sonoelectronics - Complete sonoelectronic camera prototype fabrication, and carry out laboratory characterization and test-tank demonstration. Carry out sonoelectronic integration for air-couples arrays including acoustic matching and electronic read-out technologies. ($21.5M)
- HERETIC - Complete integration of HIT device arrays with bias and control circuitry on GaAs substrates; complete integration of micro-jet, micro-nozzle or micro-thermionic arrays with bias and control circuitry over Si substrates. ($10.0M)
- Advanced Microelectronics (AME) - Demonstrate circuit and modeling of a full-scale system (e.g. image processing system) featuring terascaled-compatible devices and associate technology far beyond the existing industry roadmap. ($10.0M)
- VLSI Photonics - Develop VLSI heterogeneous integration technology and integrate micro-opto-mechanical components with VLSI chips; develop system-level CAD tools. ($20.0M)

(U) FY 2001 Program:

- Silicon RF program - Develop electronic ground plane technology that provides minimal phase shift and high reflectivity. Demonstrate integration processes for all layers and begin development of combined control function for electronic RF aperture. ($23.0M)
- Sonoelectronics - Integrate advanced transducer and acoustic-lens technologies into prototype camera. Demonstrate lab-proven imager in very-shallow-water (VSW) field setting. Carry out laboratory demonstration of an air-coupled array as an electronically-steered microphone array. ($22.9M)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology, PE 0602712E, Project MPT-02

- HERETIC - Demonstrate HIT devices on GaAs having 2x the specific heat-removal capacity as the best COTS TE coolers; demonstrate micro-jets, micro-nozzles, or micro-thermionic emitters on Si having 5x the heat-removal capacity as the best convective air or liquid cooling systems. ($10.0M)
- VLSI Photonics - Demonstrate SAR processor using VLSI Photonics technologies; showcase reconfigurable cross-connect switching. Demonstrate rapid parallel access to memory using optical interconnection. ($23.0M)

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	74.5	87.9	80.7	90.9
Appropriated	82.1	N/A	N/A	N/A
Current Budget	74.5	87.9	87.5	78.9

(U) **Change Summary Explanation**:

FY 1998 Decrease reflects rephasing of Advanced Microelectronic Devices efforts. The Defense Microelectronics Activity efforts will be transferred by DD1415 to the Defense Logistics Agency.

FY 2000 Increase reflects expanded emphasis in sonoelectronics, VLSI Photonics, silicon RF, and integrated fluidic cooling development.

FY 2001 Decrease reflects completion of Advanced Microelectronics, High Power Electronics and Digital Receiver technology efforts.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 1998	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research				R-1 ITEM NOMENCLATURE Materials and Electronics Technology, PE 0602712E						
COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Cryogenic Electronics MPT-06	18,404	8,203	11,546	12,000	15,000	16,000	16,000	16,000	Continuing	Continuing

(U) **Mission Description**: Thin film electromagnetic materials have reached a stage of development where specific applications can be identified in electronic devices and circuitry for military systems. Films are deposited and patterned to form electromagnetic components in ways that are similar to, and compatible with, the processes of conventional semiconductor manufacturing. Such electromagnetic components, as well as complementary metal oxide semiconductors (CMOS), work best at lower temperatures, so that cryogenic packaging generally will be required for highest performance. Thin-film high temperature superconducting (HTS) components packaged with cryogenic devices are being applied to radars, electronic warfare suites, and communications systems to enhance performance by more than an order of magnitude while reducing size and power requirements. Particular demonstrations include an upgraded ship-defense radar (SPQ-9B) with 100X greater detectability of missiles in littoral clutter and communications receivers with greater immunity to interference. Highly dependable and inexpensive cryocoolers are being developed for these applications. These latter development efforts include the exploration of techniques to improve the performance of solid-state thermoelectric materials as well as their overall performance in applications ranging from communications to computing.

(U) **Program Accomplishments and Plans**:

(U) FY 1998 Accomplishments:

- Cryogenics Technologies. ($14.4M)
  - Demonstrated a fully functional Cryo-Radar, with 103 dB dynamic range, 15 dB greater than present performance, showing capability to detect targets over that range and an ability to address the defense of surface ships to attacking missiles.
  - Demonstrated, in flight test, a multi-band receiver capability in Joint Airborne SIGINT (Signals Intelligence) Avionics Family (JASAF) configuration.
  - Demonstrated capability for detection of low-level unintended radiation at ranges exceeding 50 km.
  - Demonstrated an improved analog to digital (A/D) converter employing cryogenic components.
  - Demonstrated a low-cost (less than $2,500), highly reliable (greater than 30,000 hr) Sterling cycle cryocooler that delivers 5 watts at 80K with less than 200 watts of total power.
- Thermoelectric Materials and Devices. ($4.0M)
  - Demonstrated a thermoelectric cooler that provides a reduction in temperature greater than 50°C in a single stage.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 2 Applied Research	R-1 ITEM NOMENCLATURE: Materials and Electronics Technology, PE 0602712E, Project MPT-06

(U) FY 1999 Program:

- Cryogenics Technologies. ($3.2M)
  - Insert cryogenic packages in communication transceivers that mitigate electromagnetic interference effects.
- Thermoelectric Materials and Devices. ($5.0M)
  - Demonstrate thermoelectric coolers that can achieve 100°C cooling in less than three stages as compared to the current seven stages.
  - Demonstrate potential benefit of efficient power generation from thermoelectric devices operating at high temperature (>500°C).

(U) FY 2000 Program:

- Cryogenics Technologies. ($6.4M)
  - Complete adaptation of cryocoolers in microelectronics packages for communications transceivers.
  - Develop devices and components, based upon superconducting and other electromagnetic materials, that in a cryogenic environment will provide a 5-10X range improvement over conventional means for detection of low-level signals.
- Thermoelectric Materials and Devices. ($5.1M)
  - Demonstrate thermoelectric coolers that can achieve 100°C cooling in two stages or less.
  - Demonstrate >100% more power generation (per unit size) utilizing thermoelectric converters than those in use prior to 1998.

(U) FY 2001 Program:

- Cryogenics Technologies. ($9.0M)
  - Fabricate a cryogenic module, operating as a front-end preselector, to enhance the sensitivity of a receiver to detect low-level emitters in the presence of multiple interferors.
  - Design a complete cryogenic receiver module, incorporating tunable high temperature superconducting (HTS) antenna/preselector and digital microelectronics (with HTS embedded passives), displaying unsurpassed sensitivity and interference rejection.
- Thermoelectric Materials and Devices. ($3.0M)
  - Demonstrate a cooler or thermal converter that is competitive with phase change systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 2 Applied Research	R-1 ITEM NOMENCLATURE: Materials and Electronics Technology, PE 0602712E, Project MPT-06

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	18.4	8.2	11.5	20.0
Appropriated	18.4	N/A	N/A	N/A
Current Budget	18.4	8.2	11.5	12.0

(U) **Change Summary Explanation**:

FY 2001 Decrease reflects reduction in the number and complexity of cryocooler and superconducting quantum devices demonstrations.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE May 1998		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research				R-1 ITEM NOMENCLATURE Materials and Electronics Technology, PE 0602712E						
COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Military Medical/Trauma Care Technology MPT-07	16,348	2,914	0	0	0	0	0	0	0	N/A

(U) **Mission Description:** The DARPA Combat Casualty Care program has two major segments: (1) Advanced Biomedical Technology (ABT) and (2) Ultrasonic Diagnostic Imaging. The ABT segment exploits DARPA's unique leadership role in the electronics and information sciences to project advanced medical care into the far-forward battlefield area to effect early, successful clinical intervention. This program is developing lightweight personnel status monitors (PSMs) permitting casualty identification and localization. Additional sensor capabilities will be developed through a "smart tee-shirt," called the sensate liner, which is a fabric woven with fiberoptic, piezoelectric and other fibers with additional microsensors, to provide an entire suite of sensors for vital signs and physiologic monitoring. Wounded soldiers could be evacuated in a critical care Life Support for Trauma and Transport (LSTAT) pod which will function like an autonomous single-patient hospital intensive care unit. Funds for this effort (LSTAT) will be transferred to the Army in FY 1998 for execution.

(U) The Ultrasonic Diagnostic Imaging segment is developing high-fidelity diagnostic imaging primarily for the far-forward battlefield environment. The emphasis of this effort is on enhancing and miniaturizing biomedical applications of ultrasound. For example, in conventional ultrasound imaging, the medium (i.e., human tissue) is inhomogeneous and scatters the signal, which blurs the image. The processes for developing high-resolution imaging will build upon the emerging technology of adaptive acoustics, the displays of which are intuitive and easily interpreted by the combat medic and physician.

(U) This work does not duplicate any efforts of the Military Services or the National Institutes of Health. A Memorandum of Agreement exists between the Army Medical Department and DARPA.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Advanced Biomedical Technology. ($9.3M)
  - Completed sensor development for PSM system and transitioned to the Army.
  - Completed microminiaturized oxygen saturation sensor.
  - Developed and integrated the sensate liner's suite of microsensors.
  - Developed virtual mock-up of next generation LSTAT and transitioned to the Army.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology, PE 0602712E, Project MPT-07

- 3-D Ultrasound. ($7.0M)
  - Continued development, test and evaluation of 2-D array ultrasound transducer for portable applications.
  - Continued digital signal processing (DSP) for high-resolution, high signal-to-noise (S/N) ultrasound image.

(U) FY 1999 Program:

- 3-D Ultrasound Technologies. ($2.9M)
  - Complete ultrasound enhancements for scattering, deaberration, and beam forming and transition to the Services.

(U) FY 2000 Program: N/A

(U) FY 2001 Program: N/A

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	16.3	2.9	0	0
Appropriated	21.5	N/A	N/A	N/A
Current Budget	16.3	2.9	0	0

(U) **Change Summary Explanation**:

FY 1998 Decrease reflects transition of the Advanced Biomedical Technology program to eventual end users and completion of ultrasonic imager development efforts. DD 1415 will transfer the LSTAT program to the Army. ($3.9M)

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Advanced Aerospace Systems; PE 0603285E

COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Aerospace Systems ASP-01	0	0	*13,000	19,000	23,000	5,000	5,986	9,986	Continuing	Continuing

* Continuation of program initiated in FY 1998 under PE 0602702E, Project TT-07, Aeronautics Technology.

(U) **Mission Description**: The Advanced Aerospace Systems program element is budgeted in Budget Activity 3: Advanced Technology Development because it will address high payoff opportunities to dramatically reduce costs associated with advanced aeronautical systems or provide revolutionary new system capabilities for satisfying current and projected military mission requirements. Research and development of integrated system concepts, as well as enabling vehicle subsystems will be conducted.

(U) The supersonic Low Cost Cruise Missile Interceptor (SSLCCMI) program will demonstrate a low cost supersonic air platform with a low cost uncooled infrared (IR) sensor to provide cruise missile defense by exploiting large rear aspect IR signatures and overtaking incoming missiles from the rear. The program will leverage off the existing miniature air-launched decoy (MALD) program's low cost technology and off board surveillance and tracking sensors to provide tail-on missile end game opportunities.

(U) The Navy and the Marine Corps have a need for affordable, survivable, vertical take-off and landing (VTOL) unmanned air vehicles (UAV) to support dispersed units in littoral and urban areas. The Defense Advanced Research Projects Agency (DARPA), in partnership with the Office of Naval Research (ONR) and industry, have formulated a program to explore two innovative vertical take-off and landing (VTOL) concepts with the potential for significant performance improvements that would satisfy stressing mission needs. The first, an advanced Canard Rotor/Wing (CRW) concept, offers the potential for a high speed (350 knots), rapid response capability from a VTOL unmanned air vehicle (UAV) with significant range (500 nm) and stealth improvements as compared to other VTOL concepts. Detailed design, fabrication and flight test of this scaled vehicle concept will be conducted to validate the command and control and propulsion system required for vertical take-off, landing and hover via a rotating center wing which is stopped and locked in place for efficient high speed cruise. The second concept (A160), will exploit a hingeless, rigid, in-plain rotor concept to produce a VTOL UAV with very low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. This unique concept offers the potential for significant increases in VTOL UAV range (>3000 nm) and endurance (>40 hours). Detailed design, fabrication and testing of this concept will be conducted to establish its reliability, maintainability and performance. The A160 and CRW programs were initiated in FY 1998 under PE 0602702E, TT-07, Aeronautics Technology.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E, Project ASP-01

Since both efforts have matured beyond the Applied Research phase of development to the demonstration and prototype levels, it is more appropriately budgeted in the Advanced Technology Budget Activity, PE 0603285E.

(U) **Program Accomplishments and Plans:**

(U) FY 2000 Program:

- Continue fabrication and conduct hardware in-the-loop and ground testing of Canard Rotor/Wing (CRW) and A160 concepts. ($10.0M)
- Supersonic Low Cost Cruise Missile Interceptor (SSLCCMI): Establish preliminary and final design after conducting cost and performance trades. Determine seeker and turbine engine integration and configuration. Refine operational concepts and requirements. ($3.0M)

(U) FY 2001 Program:

- Supersonic Low Cost Cruise Missile Interceptor (SSLCCMI): Conduct engine and low cost miniature sensor testing, fabricate, assemble and conduct ground and early risk reduction testing of air vehicle. Initiate detail test planning for flight demonstration.($10.0M)
- Complete fabrication and conduct flight testing of CRW and A160 concepts. ($9.0M)

(U) **Program Change Summary:** *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	0	0	0	0
Appropriated	N/A	N/A	N/A	N/A
Current Budget	0	0	13.0	19.0

(U) **Change Summary Explanation:**

FY 2000-01 Increases reflect transfer of the CRW and A160 efforts from PE 0602702E, Project TT-07, Aeronautics Technology; and initiation of the SSLCCMI program.

(U) **Other Program Funding Summary Cost:** N/A

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E, Project ASP-01

(U) **Schedule Profile**:

Plan	Milestones
Oct 99	CRW Critical Design Review.
Nov 99	Conduct Supersonic Low Cost Cruise Missile Interceptor (SSLCCMI) Requirements Definition.
Jun 00	Complete CRW ground testing.
Aug 00	Complete A160 flight control system testbed flights.
Oct 00	Perform SSLCCMI Preliminary Design Review after conducting performance trades.
Oct 00	Canard Rotor/Wing (CRW) Detailed Design Review.
Oct 00	CRW Rollout of Air Vehicle No. 1.
Jan 01	Flight test CRW and A160 Air Vehicles.
Mar 01	Demonstrate SSLCCMI low cost seeker requirements.
Jun 01	CRW flight tests completed.
Jun 01	SSLCCMI demonstrates higher thrust output of TJ-50 derivative.
Dec 01	A160 final flight test of Air Vehicles No. 1, 2, and 3 Complete.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 1998	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E, R-1 #43					
COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Electronics Technologies	**281,909**	**244,737**	**247,014**	**245,348**	**235,109**	**244,417**	**255,979**	**254,979**	**Continuing**	**Continuing**
Uncooled Integrated Sensors MT-03	8,669	11,000	3,000	0	0	0	0	0	0	N/A
Electronic Module Technology MT-04	68,268	65,992	61,142	47,395	53,999	81,363	84,925	86,925	Continuing	Continuing
Tactical Information Systems MT-05	29,472	36,496	19,640	22,748	21,100	0	0	0	0	N/A
Microwave and Analog Front End Technology (MAFET) MT-06	18,250	4,000	0	0	0	0	0	0	0	N/A
Centers of Excellence MT-07	3,852	4,000	0	0	0	0	0	0	0	N/A
Manufacturing Technology Applications MT-08	29,162	25,200	20,253	0	0	0	0	0	0	N/A
Advanced Lithography MT-10	51,078	26,500	28,000	24,000	27,500	24,754	24,754	24,754	Continuing	Continuing
Microelectromechanical Systems (MEMS) MT-12	73,158	71,549	78,979	80,000	79,000	88,300	96,300	93,300	Continuing	Continuing
Mixed Technology Integration MT-15	0	0	36,000	71,205	53,510	50,000	50,000	50,000	Continuing	Continuing

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E

(U) **Mission Description:** The Advanced Electronics Technology program element is budgeted in the Advanced Technology Development Budget Activity because it seeks to design and demonstrate state-of-the-art manufacturing and process technologies for the production of various electronics and microelectronic devices, sensor systems, actuators, and gear drives that have both commercial and military applications. Introduction of advanced product design capability and flexible, scalable manufacturing techniques will enable the commercial sector to rapidly and cost-effectively satisfy military requirements and enhance the U.S. industrial base.

(U) The Uncooled Integrated Sensors project addresses a long standing Defense requirement for uncooled, solid state advanced infrared sensor arrays for major weapons systems that do not require costly cryogenic cooling packages.

(U) The Electronic Module Technology project is a broad initiative to substantially decrease the cost and increase the performance of weapon systems through the timely insertion of state-of-the-art electronic modules. Electronic module technology addresses the design and fabrication of various types of digital, analog, and mixed signal modules consisting of electronic, electro-optical and micro-mechanical components. It includes traditional approaches such as printed circuit boards and emerging technologies such as high density Multichip Modules (MCMs).

(U) The Tactical Information Systems project contains three major programs: Head Mounted Displays (HMD), Smart Modules, and Warfighter Visualization. The Head Mounted Display program is developing world-class miniature displays and integrating these displays into head and helmet mounted configurations for use by pilots, combat vehicle crews and individual warriors, as well as for virtual environments and simulation. Smart Modules is a program to design and develop prototype modules, using core technologies that sense, think, and communicate, and integrate them into selected personal information products. Warfighter Visualization is a program to demonstrate the feasibility of combining real-time visual images of the environment with geospatially registered computer generated information for use by individual mounted and dismounted warfighters.

(U) The goal of the Manufacturing Technology Applications project is to reduce the cost and acquisition lead time of future military systems by integrating manufacturing process considerations during the product design phase, and by demonstrating high efficiency multi-product prototype factories. This project will also enable manufacturers to economically produce military variants of their commercial products in limited quantities through the introduction of flexible process technologies. It is scheduled to complete after FY 2000.

(U) Advanced Lithography technology has enabled the dramatic growth of integrated circuit capability. Advances have led directly to improvements in electronic and computing systems performance in terms of speed, power, weight and reliability.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E

(U) The Microelectromechanical Systems (MEMS) project is a broad and cross-disciplinary initiative to develop an enabling technology that merges computation with sensing and actuation to realize new systems for both perceiving and controlling weapons systems, processes and battlefield environments. Using fabrication processes and materials similar to those that are used to make microelectronic devices, MEMS conveys the advantages of miniaturization, multiple components, and integrated microelectronics to the design and construction of integrated electromechanical systems. The microfluidic molecular systems program will address issues centered around the development of automated microsystems that integrate biochemical fluid handling capability along with electronics, opto-electronics and chip-based reaction and detection modules to perform tailored analysis sequences for monitoring of environmental conditions, health hazards, and physiological states.

(U) The goal of the newly established Mixed Technology Integration project is to revolutionize the integration of mixed technologies at the micrometer/nanometer scale. This will produce low-cost, lightweight, low-power 3D microsystems that improve battlefield awareness and the operational performance of military platforms. This project will leverage industrial manufacturing infrastructure to produce mixed-technology microsystems that will revolutionize the way warfighters see, hear, taste, smell, touch and control environments.

(U) Two on-going DARPA projects complete in FY 1999: MAFET (MT-06) and Centers of Excellence (MT-07). The Microwave and Analog Front End Technology (MAFET) project has been directed at significantly reducing non-recurring costs for military microwave/millimeter wave sensor systems through improved computer aided design capabilities. The Centers of Excellence project has financed demonstration, training and deployment of advanced manufacturing technologies.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Advanced Electronics Technologies, PE 0603739E

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
*Uncooled Integrated Sensors MT-03	8,669	11,000	3,000	0	0	0	0	0	0	N/A

*Formerly titled IR Focal Plane Array

(U) **Mission Description:** The Uncooled Integrated Sensors project addresses the technology necessary to produce affordable, infrared (IR) sensor arrays, essential to major weapon systems. The focal plane array consists of a two dimensional detector array sensitive in a broad spectral range, integrated with unique signal processing to enhance performance and provide more efficient utilization of the information. The critical elements of the technology addressed in this program include the infrared material, detector array fabrication, read-out electronics, cryogenic packaging and testing, and module assembly. Processing and fabrication techniques focus on the production of affordable arrays, at low volume, in the configurations required by weapon systems. Performance enhancements in uncooled infrared and near-infrared sensors are also being addressed to provide an integrated, broadband two dimensional sensor array without the cryogenic package usually associated with infrared sensors. Elimination of the cryogenic package dramatically reduces the cost of the sensor module, and provides a sensor package compatible with a wide range of system applications, including navigation, targeting and manportable systems. The solid state integrated sensor also solves the problem of blooming in the presence of high intensity sources, which is encountered with current low light level visible and near infrared sensors. Arrays will be built in the configuration required for missile seekers, target acquisition and navigational platforms, search and track, and threat warning systems.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:
- Demonstrated uncooled infrared array with thermal sensitivity of 0.05 degrees. ($3.7M)
- Demonstrated low light level solid state imager with anti-blooming protection. ($5.0M)

(U) FY 1999 Program:
- Fabricate and test integrated uncooled infrared array and solid state, low light level array with anti-blooming protection. ($7.0M)
- Establish feasibility of a solid state imager with spectral response beyond night vision goggles. ($4.0M)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E, Project MT-03

(U) FY 2000 Program:

- Demonstrate integrated imaging, consisting of 480 X 640 uncooled infrared fused with solid state low light level sensor, with performance required for man-portable systems and smart munitions. ($2.1M)
- Demonstrate 480 X 640 monolithic uncooled infrared sensor with one pixels, demonstrating a five times increase in the sensitivity of uncooled sensors. ($0.9M)

(U) FY 2001 Program: No funding requested.

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	8.7	11.0	3.0	0
Appropriated	8.7	N/A	N/A	N/A
Current Budget	8.7	11.0	3.0	0

(U) **Change Summary Explanation**: N/A

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Plan	Milestones
Sep 98	Evaluation of large area uncooled sensor with less than 0.05 degree thermal sensitivity.
Jan 00	Evaluation of integrated sensor with broad band infrared response.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 1998	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E					
COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Electronic Module Technology MT-04	68,268	65,992	61,142	47,395	53,999	81,363	84,925	86,925	Continuing	Continuing

(U) **Mission Description:** The Electronic Module Technology Project is a broad initiative to substantially decrease the cost and increase the performance of weapon systems through the timely insertion of state-of-the-art electronic modules. Electronic module technology addresses the design and fabrication of various types of digital, analog, and mixed signal modules consisting of electronic, electro-optical and micro-mechanical components. It includes traditional approaches such as printed circuit boards and emerging technologies such as high density Multichip Modules (MCMs).

(U) The project has four major objectives: (1) shorten the overall design, manufacture, test, and insertion cycle for advanced electronic subsystems; (2) advance the state-of-the-art in electronic interconnection and physical packaging technology to allow circuits to operate close to their intrinsic maximum speed with less overhead in terms of volume, weight and cost; (3) provide a robust manufacturing infrastructure for electronic modules; and (4) demonstrate the system level payoff of electronic module technology through advanced technology demonstrations (ATDs).

(U) The project has the following major elements: Photonic Analog/Digital (A/D) Conversion; Optical Micro-Networks (OMNET); Distributed Robotics; Design Support for mixed Technology Integration (Composite CAD) and the Molecular-Level Large-Area Printing (MLP) program. OMNET seeks to demonstrate new paradigms for integrating electronic, electromechanical, and electro-optical components to enable small, lightweight, battlefield information systems. Distributed Robotics is a new effort to integrate developments in MEMS, power sources, communications, and advanced microelectronics to design, construct and field multiple, high-performance, mobile, autonomous systems. Composite CAD seeks to develop the design tools (concept exploration, analysis, optimization and verification) to allow thousands of analog, digital, optical, MEMS and microfluidic devices to be integrated into "systems-on-a-chip" and other highly integrated mixed technology systems. The MLP program is exploring approaches to 'print' MEMS devices on large surfaces.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Advanced Electronics Technologies, PE 0603739E, Project MT-04

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Completed ASEM program that reduced non-recurring engineering costs for designing and inserting multi-chip modules. ($6.3M)
- Completed the Multichip Integration (MCI) program that improved substrate fabrication, demonstrated reductions in Multichip Modules (MCM) manufacturing costs, and technology insertions. ($14.3M)
- Optical Micro-Networks (OMNET) - Downselected amongst heterogeneous integration technologies and demonstrated multi-functional integration of electronic, electro-mechanical and optoelectric components targeted to military information systems. ($12.7M)
- Distributed Robotics - Initiated effort to put together, in one package, low-weight (<2 kg), high-performance payloads including sensors, imagers, countermeasures, designators, communications, and munitions. ($8.8M)
- Composite CAD - Integrated a composable design capability for single chip electronics and MEMS systems. Developed models with parameters optimized for manufacturing variances. Initiated behavior modeling of mixed technology devices. ($17.5M)
- Molecular-level, Large-area Printing (MLP) - Established preliminary micro-molding process using commercially available (CD manufacturing) tool; initiated studies of alternative micro-printing processes (letterpress, gravure, tropomorphic). ($8.7M)

(U) FY 1999 Program:

- OMNET - Demonstrate integrated optoelectronic transceivers and optical switches for reconfigurable interconnections of sensors to processors and the ability to distribute computation across military platforms 1-100 meters in length for future Electronic Warfare/digital radar and image processors. ($10.0M)
- Distributed Robotics - Construct the unit platforms, integrate commercial or demonstrated technology elements (e.g., imagers, MEMS, wireless systems), and define multiple, cooperative functions for selected military applications. ($13.0M)
- Composite CAD - Continue to develop the mixed domain software (kinematic, electric, electrostatic, and fluidic) analysis of micro-machined devices, systems of devices and corresponding electronic circuits to support the design of composite electronic sensors and systems. ($22.0M)
- Photonic A/D - Initiate photonic A/D converter development to achieve breakthrough in high speed A/D conversion. ($9.0M)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E, Project MT-04

- MLP - Complete experimental characterization of release agents for micromolding; select candidate printing processes (≤2) and compatible readout process for development; and demonstrate writing on non-flat surfaces with radii of curvature in the range 1m to 1cm. ($12.0M)

(U) FY 2000 Program:

- Phototonic A/D - Demonstrate key optical clock, optical sampler and related optical technologies for photonic A/D converters operating in the 10-100 Giga sample per second range and identify high impact applications for this technology. ($16.1M)
- Distributed Robotics - Demonstrate feasibility of a variety of different robots (<5cm) to operate in specific military environments and their ability to adapt to varying environments and missions. Initiate effort to develop millimeter sized robots. ($20.0M)
- Composite CAD - Complete the development of systems software design and simulation capabilities for mixed technology micro-systems, including MEMS-enable designs and microfluidic (Micro-Flumes) designs. The ultimate goal of the complete systems design capability is to enable mixed technology systems-on-a-chip. Provide mixed technology design libraries, models, and test structure data to improve design quality, development time, and ability to reuse designs. ($11.0M)
- Molecular-level, Large-area Printing (MLP) - Concentrate on the development and choice of non-conventional large-area, molecular-level, large-area printing (MLP) techniques for a demonstration system. ($14.0M)

(U) FY 2001 Program:

- Phototonic A/D - Complete initial photonic A/D converter evaluation and finalize design for demonstration module. ($16.5M)
- Distributed Robotics - Develop prototype millimeter sized robots using fundamental behavioral control mechanisms for sensing and communicating. ($15.0M)
- Molecular-level, Large-area Printing - Concentrate on the demonstration of the use of MLP for realizing a wide area, super-high-resolution (e.g. 100-megapixel, corresponding to about 1,000 TV images) imaging system as needed, for example, for automatic threat warning. ($15.9M)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE
	May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E, Project MT-04

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	68.3	66.0	69.2	65.6
Appropriated	62.5	N/A	N/A	N/A
Current Budget	68.3	66.0	61.1	47.4

(U) **Change Summary Explanation**:

FY 1998 Increase reflects repricing of the final increment of the ASEM program, Robotics and Composite CAD efforts.
FY 2000 Decrease reflects completion of the composite CAD Program.
FY 2001 Decrease reflects reprioritization of Agency requirements.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Plan	Milestones
Jun 98	Demonstrate efficient 3-D electromagnetic modeling capability.
Aug 98	Complete testing of integrated optoelectronic devices.
Sep 98	Demonstrate MCM substrates with integrated passive components.
Jul 99	Demonstrate mixed energy domain analysis capability for integrated technology devices.
Aug 99	Demonstrate optical micronetwork with reconfiguration capability.
Nov 99	Initial prototype of tightly integrated adaptive payload technology.
Apr 00	Characterization of single crystal semiconductors on amorphous surfaces.
Jun 00	Establish overlay capabilities for MLP.
Sep 00	Design & initiate fabrication of demonstration sensor array.
Sep 00	Demonstrate initial PCM designs (<10 femtosecond jitter, 100 on W output).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Advanced Electronics Technologies, PE 0603739E

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Tactical Information Systems MT-05	29,472	36,496	19,640	22,748	21,100	0	0	0	0	N/A

(U) **Mission Description:** This project is a major DoD effort to develop the technology for displays and portable information systems for use in a variety of military systems. The project has two major efforts: Smart Modules and Warfighter Visualization. Smart Modules will design, develop, and integrate prototype modules, using core technologies that sense, think, and communicate into selected personal information products. Warfighter Visualization efforts demonstrate the feasibility of combining real-time visual images of the environment with geospatially registered computer generated information for use by individual mounted and dismounted warfighters.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Demonstrated prototype electric countermeasures system integrated into a soldier worn vest. The computational capability developed in the FY 1997 program was augmented with two PC cards containing ECM circuitry that allowed dismounted soldiers to instantly locate radio emissions from hostile forces. Demonstrated a prototype water proof computer for underwater use in SEAL and Explosive Ordnance Disposal applications. ($15.4M)
- Continued efforts to develop hand and head motion tracking technologies. Tracking head movement will allow a computer to display information to a head mounted display that is registered in the geospatial direction that the individual is looking. Tracking hand motion will allow a computer to recognize pointing and gestures as input mechanisms instead of using a keyboard. ($6.4M)
- Demonstrated image capture and geospatial registration of icons on terrain in a moving vehicle. The vehicle was equipped with video cameras that provided a 360 degree view. Inside the vehicle, a person wearing a head tracked, head mounted display was able to look around and view the images obtained from the cameras. Icons and graphical images generated by a computer were overlayed on the camera image in the head mounted display. These images were registered with the viewed real-world terrain. ($7.7M)

(U) FY 1999 Program:

- Demonstrate a novel capture device that incorporates signal and data processing in a 3-D package for use by individual soldiers. This miniature device, weighing only a few ounces, will be able to capture an image and rapidly analyze movement or correlate images with all processing done on the focal plane.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E, Project MT-05

The camera will be able to be worn by individual soldiers and communicate via a radio to and from geographic information system databases. ($9.2M)

- Demonstrate a wearable computer incorporating wireless communication in a one pound, one watt configuration. This represents a 3x improvement in weight and a 10x improvement in power over current technology. The wearable computer will be used in a wide variety of applications by the small unit operations soldier. ($9.9M)
- Demonstrate prototype capability for dismounted soldiers to view the real world with overlayed graphic symbology. This capability will allow the soldier to receive visual information that is relevant to his/her mission time or location. It will also allow the soldier to interrogate databases containing information about the specific objects in his/her viewing environment. ($5.8M)
- Demonstrate prototype "see-through" tank concept. This capability will allow a "buttoned-up" tank crew wearing head mounted displays to view the outside world as though the tank were made of glass. This will be accomplished by placing cameras on the outside of the tank that provide inputs to a mapped memory. Images will be fed to the users' head mounted display depending upon the direction that the user is looking. This capability will significantly enhance the situation awareness of the tank crew. ($6.5M)
- Demonstrate a capability to obtain one-dimensional and two-dimensional data from a submarine sensor suite and configure these data into a 3-dimensional image covering 360 degrees that is provided to a head tracked, head mounted display. This capability will be used by a submarine conning officer to demonstrate an enhanced capability for under ice submarine navigation. ($5.1M)

(U) FY 2000 Program:

- Warfighter Visualization:
  - Demonstrate a non-metallic tracking system for mounted and dismounted soldiers. System gives accurate low-lag estimates of head position and pose for body-oriented battlefield visualization. System is necessary for visual data correlation system, and see-through combat vehicle applications. ($3.3M)
  - Develop a two-chip image processing system for integration into battlefield smart camera. This system will shrink multiple electronics boards into a small enough package for applications in night vision goggles, UAV surveillance, and headworn image stabilization. ($4.3M)
  - Demonstrate a prototype supernormal listening system for enhanced battlefield awareness. This system will give enhanced hearing capability and improved situation awareness and voice communications in both quiet and loud ambient noise environments. ($3.6M)
  - Demonstrate a prototype optical tracking system using bodyworn camera. This system will give position coordinates in environments where GPS is unavailable, and give more accurate position coordinates where it is available. This capability is essential for urban and in-building small-unit operations. ($4.6M)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E, Project MT-05

- Demonstrate prototype high resolution single chip tactile display system. System will give 10X lower power and 100X higher resolution than existing tactile systems for covert battlefield alert and monitoring. Tactile display on gun for example will indicate number of rounds left in magazine using sense of touch. ($3.8M)

(U) FY 2001 Program:

- Warfighter Visualization:
  - Demonstrate a two camera prototype image sensor system giving high resolution imaging over 360 degrees with low delay. This system is essential for the realization of a cost effective "see-through" vehicle. ($5.6M)
  - Demonstrate an experimental low-cost, light weight perimeter monitoring system for dismounted soldiers. System creates a protection "dome" around sleeping soldiers to alert against intruders. ($4.1M)
  - Demonstrate a single chip localization system for battlefield awareness. Chips use time of flight measurements and triangulation to determine spatial coordinates while maintaining low probability of detection. ($5.0M)
  - Demonstrate a prototype bodyworn 3D mission re/planning tool. System allows virtual "walk-through" of operations area and real-time editing. System also gives visualization of dynamic multi-sensor I/O on the battlefield. ($4.6M)
  - Demonstrate an automated system for 3D model-extraction from ground level video. System builds up 3D models for mission planning "walk-throughs" using views from vehicles, robots, UAV's and other sources. ($3.4M)

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	29.5	36.5	39.5	42.7
Appropriated Budget	33.6	N/A	N/A	N/A
Current Budget	29.5	36.5	19.7	22.7

(U) **Change Summary Explanation**:

FY 1998 Decrease reflects the deferral of boot-mounted navigation device initiative.
FY 2000-01 Decreases reflect completion of Smart Module Program.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E, Project MT-05

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Plan	Milestones
Feb 99	Demonstrate 1 pound, 1 watt wearable computer system.
Feb 99	Real world viewing with computer generated graphic overlay demonstration.
Dec 99	Build and test Advanced Humanistic Platform prototype.
Dec 99	Develop hybrid sensor tracking features and including "smart camera" functions to allow collaborative updates between soldiers.
Jul 00	Develop real-time visual data correlation system in dismounted and mounted warrior applications.
Jul 01	Demonstrate dynamic multi-sensor I/O in both dismounted and mounted military applications.

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APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Advanced Electronics Technologies, PE 0603739E

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Microwave and Analog Front End Technology MT-06	18,250	4,000	0	0	0	0	0	0	0	N/A

(U) **Mission Description:** Microwave and millimeter wave technology for DoD electronic weapon systems is at a critical crossroads. Great progress has been made under the microwave and millimeter wave integrated circuit (MIMIC) program in terms of maturing the gallium arsenide industrial community. The DoD is now far ahead of the commercial world in microwave and millimeter wave technology in terms of performance characteristics. However, in many cases, radio frequency (RF) sub-system costs are still a major impediment to fielding DoD weapon systems. Material, processes and design technology advances must be undertaken to sustain an effective defense capability and to maintain U.S. dominance in this critical technology area. The MAFET program has addressed this problem by: (1) reducing design time and cost for every RF system being developed or upgraded through an improved microwave/millimeter wave design environment; (2) breaking the very expensive cycle and time-consuming current practice of design-build-test--redesign-rebuild-retest; (3) establishing repeatable, robust processes to produce high frequency components; (4) making strategic investments in critical passive, packaging and integrated circuits devices needed for millimeter wave systems; and (5) investigating revolutionary solutions to the long-standing problem of insufficient power in solid-state radar and communications transmitters.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Completed microwave/millimeter wave computer aided design environment. Demonstrated design environment effectiveness. Continued implementation of Microwave Hardware Description Language (MHDL). ($6.8M)
- Completed advanced sensor technology developments in the areas of: advanced fabrication, packaging, and multichip assembly (MCA) foundries. In the fabrication area, demonstrated: (1) production InP HEMT and HBT millimeter wave processes; (2) advanced manufacturing processes for: high power and high efficiency, and high dynamic range, capability; and (3) highly manufacturable and reliable HBT high power amplifiers. In the packaging area, demonstrated: (1) a 10x cost reduction in plastic HDI module fabrication technology; and (2) a 7x RF interconnect/package reduction due to embedded transmission lines and advanced multilayer interconnect. In the foundry area, demonstrated a 5x reduction in MCA production cost. ($5.2M)
- (1) In novel high-power transistor area, demonstrated 5-W SiGe HBT solid-state power amplifier (SSPA) having near-50% power-added efficiency (PAE) at X-band; demonstrated 10-W GaN MODFET having PAE=50% in X band;

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demonstrated 25-W SiC MESFET having PAE=45% in X band. (2) In quasioptics area, continued development of solid-state quasioptical Ka-band sources with high output power and high coherence; completed and demonstrated numerical design tool. (3) In MEMS-switch area, demonstrated 4-bit true-time-delay phase shifter in (a) X-Band with 2-dB total loss, and (b) Ka-Band with 3-dB loss; demonstrated 20/44-GHz dual-frequency MEMS-switched planar antenna. (4) In micromachined circuits and novel thermal management area, demonstrated micromachined W-band Wilkinson combiners in Si substrates; demonstrated Flourinert cooling of a 10-W X-band MMIC and a 1-W Ka-band MMIC. ($6.2M)

(U) FY 1999 Program:

- In quasioptics area, demonstrate a set of quasioptical grid-, array-, card-, and slab-combined power amplifiers including (a) a 100-W 50%-PAE card amplifier at 10 GHz, (b) a 20-W-output >25%-PAE array amplifier at 35 GHz, (c) a 20-W-output 15-to-20%-PAE grid amplifier at 40 GHz, (d) a 10x10-element 10-W electronically-steerable array amplifier at 44 GHz, and (e) a 5-W 20%-PAE slab-amplifier at 94 GHz. ($2.0M)
- In MEMS-switch area, demonstrate MEMS-tunable Chebyshev filter operating at 20 and 45 GHz; demonstrate MEMS-array transmitting beam-steerer at 44 GHz. ($1.0M)
- In micromachined circuits and novel thermal management area, demonstrate a micromachined SSPA ("W-Band Power Cube") having 2 W/in^2 intensity radiated from top facet. The power cube will be fabricated with InP Power MMICs that are thermally managed by bump bonding and are coupled to free space by Si-micromachined feed-line and planar-antenna structures. ($1.0M)

(U) FY 2000 Program: N/A

(U) FY 2001 Program: N/A

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	18.3	4.0	0	0
Appropriated	23.2	N/A	N/A	N/A
Current Budget	18.3	4.0	0	0

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E, Project MT-06

(U) **Change Summary Explanation**:

FY 1998 Decrease reflects accelerated program phase down; anticipated completion by the end of FY 1999.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Plan	Milestones
Sep 98	Ultra-low-cost SiGe T/R modules.
Dec 98	Demonstrate 10-W millimeter wave power amplifier array.
Jan 99	Demonstrate millimeter wave micromachined solid-state power amplifier.
Mar 99	Demonstrate millimeter wave beam steering module.
Jun 99	Demonstrate > 100-W low cost X-band electronically steerable source.
Sep 99	Demonstrate full interoperability of CAD vendors.

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APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Advanced Electronics Technologies, PE 0603739E

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Centers of Excellence MT-07	3,852	4,000	0	0	0	0	0	0	0	N/A

(U) **Mission Description:** This project provides funding for the Robert C. Byrd Institute for Advanced Flexible Manufacturing at Marshall University. The Institute provides both a teaching factory and initiatives to local area industries to utilize computer-integrated manufacturing technologies and managerial techniques to improve manufacturing productivity and competitiveness. Training includes technologies to significantly reduce unit production and life cycle costs and to improve product quality.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Completed development of internetting capabilities at the Institute for Advanced Flexible Manufacturing to ensure medium- and small-sized businesses have access to emerging electronic commerce and advanced technologies. ($3.9M)

(U) FY 1999 Program:

- Complete assessment of the Institute for Advanced Flexible Manufacturing's performance and transition from DoD to state/private support. ($4.0M)

(U) FY 2000 Program: N/A

(U) FY 2001 Program: N/A

(U) **Program Change Summary:** *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	3.9	4.0	0	0
Appropriated	3.9	N/A	N/A	N/A
Current Budget	3.9	4.0	0	0

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APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Advanced Electronic Technologies, PE 0603739E, Project MT-07

(U) **Change Summary Explanation**: N/A

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Plan	Milestones
Oct 98	Demonstrate advanced internetting capabilities that can be utilized by medium- and small-sized businesses to access emerging electronic commerce and advanced technologies.
Oct 99	Complete assessment and transition of the Institute from DoD to state/private support.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E					
COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Manufacturing Technology Applications MT-08	29,162	25,200	20,253	0	0	0	0	0	0	N/A

(U) **Mission Description:** Future military systems will be affordable only if the manufacturing process is considered as an integral part of product design, production takes place in flexible, multi-product factories, and if advanced manufacturing technology is combined effectively with advanced business practices. This program focuses on demonstrations of process technology combined with innovative industrial practices and will measure the improvements in cost, schedule and quality achievable in key defense product areas.

(U) The Affordable Multi-Missile Manufacturing (AM3) program is an Advanced Technology Demonstration initiated in FY 1995. The objective of AM3 is to demonstrate the feasibility of 25-50% reductions in the unit cost of tactical missiles, both in ongoing missile production programs and in new missiles and major modifications. This will be accomplished by teams of missile prime contractors, component suppliers and manufacturing equipment and software vendors who develop and demonstrate the combined effects of advanced design, manufacturing, assembly systems and processes, missile value engineering changes, and acquisition reform and business practice innovations. A major technical theme is to achieve economies across a mix of missiles to compensate for the decline in individual missile quantities. Demonstrations will be conducted in the design and manufacture of components and guidance and control/seeker assemblies for multiple missiles, including R&D and production programs.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Affordable Multi-Missile Manufacturing (AM3). ($24.3M)
  - Began AM3 Phase 3 implementation of new factory systems and new business practices at Lockheed Martin and Raytheon.
  - Completed initial design and test planning for AM3 multi-missile components and value engineering change proposals.
  - Completed initial demonstrations of supply chain technologies to fill gaps identified in AM3 Phase 1, and continued technical integration and independent cost analysis.
- Interferometric Fiber Optic Gyroscope (IFOG). ($4.9M)
  - Demonstrated flexible production of navigation grade and tactical grade IFOG units.

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- Demonstrated production of high power, stable, packaged optical sources, low cost couplers and wavelength division multiplexers.

(U) FY 1999 Program:

• Affordable Multi-Missile Manufacturing. ($25.2M)
  - Continue AM3 Phase 3 implementation of flexible multi-product assembly cells and prototype production of missile hardware.
  - Conduct initial tests of missile seekers built with the Affordable Multi-Missile Manufacturing scalable family of parts and commercial components.

(U) FY 2000 Program:

• Affordable Multi-Missile Manufacturing. ($20.3M)
  - Complete integration of flexible factory assembly areas. Deploy System Integrated Design Environment. Complete design and prototype fabrication of low-cost IMU. Complete common processor design verification test and integration. Validate electronic collaborative tools and complete supplier affordability demonstration. Complete integration of guided flight unit, gyro optics assembly fabrication, and mid-body casting demonstration.
  - Complete common seeker commercial parts test evaluation, producibility analysis, and flight test. Complete common IMU design verification test, prototype demonstration unit, and technology insertion review. Complete process design for flexible multi-product assembly cells, validate on production parts, and demonstration on production line. Complete electronic procurement and supplier integration demonstrations.

(U) FY 2001 Program: N/A

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	29.2	25.2	22.0	0
Appropriated	31.2	N/A	N/A	N/A
Current Budget	29.2	25.2	20.3	0

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(U) **Change Summary Explanation**:

FY 1998 Decrease reflects program repricing and reprogramming to SBIR program.
FY 2000 Decrease reflects AM3 program repricing in anticipation of program completion.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Plan	Milestones
Jul 98	Define AM3 common inertial measurement unit baseline architecture.
Oct 99	Complete integration of flexible factory assembly areas.
Oct 99	Complete common seeker commercial parts test evaluation, producibility analysis, and flight test.
Dec 99	Complete AM3 Phase 3 multi-missile manufacturing demonstrations.
Jan 00	Deploy System Integrated Design Environment.
Jan 00	Complete common IMU design verification test, prototype demonstration unit, and technology insertion review.
Mar 00	Complete common processor design verification test and integration.
Mar 00	Complete process design for flexible multi-product assembly cells, validate on production parts, and demonstration on production line.
Jun 00	Complete flight tests of AM3 missile seeker prototypes.
Jul 00	Complete integration of guided flight unit, gyro optics assembly fabrication, and mid-body casting demonstration.
Jul 00	Complete electronic procurement and supplier integration demonstrations.

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APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Advanced Electronics Technologies, PE 0603739E

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Lithography MT-10	51,078	26,500	28,000	24,000	27,500	24,754	24,754	24,754	Continuing	Continuing

(U) **Mission Description:** Microelectronics is a key to improved weapon system performance and lithography technology has enabled the dramatic growth in microelectronics capability over the past three decades. The improved capabilities in semiconductor technology contribute to significant system gains in speed, reliability, cost, power consumption, and weight. Advanced microelectronics technology is essential for computing and signal processing throughout essentially all military systems including command, control, communications, and intelligence; electronic warfare; and beam forming for radar and sonar. Further improvements in areas such as target recognition, autonomous guided missiles, and digital battlefield applications require microcircuits with smaller features to meet the operational speed, power, weight and volume constraints of these systems.

(U) Current microelectronics fabrication utilizes feature sizes of 0.35 microns. The Advanced Lithography Program emphasizes longer term research with expected high payoff in the fabrication of semiconductor devices with 0.1 or less micron feature sizes. These programs will develop technology for sub 0.1 micron features. Current programs in cross-cutting technologies (mask, stages, resists, metrology) and x-ray lithography will be completed in one - two years. Key subsystems of the maskless e-beam developments will be demonstrated late in the decade.

(U) **Program Accomplishments and Plans**:

(U) FY 1998 Accomplishments:

- Researched efforts for sub 0.1 micron in maskless lithography (emitter arrays and photocathodes), innovative imaging materials, and network of university efforts in novel patterning. ($19.9M)
- Completed development of cross-cutting technology in precision stages and mask making (e-beam writing and inspection) for 0.13 - 0.10 micron features. ($6.2M)
- Completed point-source x-ray lithography program. ($2.9M)
- Continued funding of the Lithographic and Alternative Semiconductor Processing Techniques (LAST) Center to develop mask technology for semiconductor device fabrication. ($17.3M)
- Continued Laser Plasma x-ray source technology. ($4.8M)

(U) FY 1999 Program:

- Continue efforts in maskless lithography, including arrays of miniature e-beam columns, and novel imaging materials and pattern transfer processes.
  - Continue network of university efforts in novel patterning. ($9.5M)

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- Complete column test stand for maskless e-beam writer. ($17.0M)

(U) FY 2000 Program:

- Continue maskless lithography techniques for lower cost, low volume production. Develop smaller features for semiconductor devices for better performance. Develop improved metrology for ultra-small devices. ($28.0M)

(U) FY 2001 Program:

- Demonstrate maskless writer and characterize performance. Continue support technology developments in metrology, resist materials, and improved stage control applicable to 0.05 micron design rules. ($24.0M)

(U) **Program Change Summary:** *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	51.1	26.5	28.0	24.0
Appropriated	51.1	N/A	N/A	N/A
Current Budget	51.1	26.5	28.0	24.0

(U) **Change Summary Explanation:** N/A

(U) **Other Program Funding Summary Cost:** N/A

(U) **Schedule Profile:**

Plan	Milestones
Jun 98	Demonstrate maskless printing of contact level using laser interferometric lithography.
Jun 99	Demonstrate switched emitter arrays for maskless lithography.
Jul 00	Demonstrate ion microcolumn for maskless lithography.
Mar 01	System demonstration of maskless charged particle writer.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E						
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Microelectromechanical Systems (MEMS) MT-12	73,158	71,549	78,979	80,000	79,000	88,300	96,300	93,300	Continuing	Continuing

(U) **Mission Description**: The Microelectromechanical Systems (MEMS) program is a broad, cross-disciplinary initiative to develop an enabling technology that merges computation with sensing and actuation to realize new systems for both perceiving and controlling weapons systems, processes, and battlefield environments. Using fabrication processes and materials similar to those that are used to make microelectronic devices, MEMS conveys the advantages of miniaturization, multiple components, and integrated microelectronics to the design and construction of integrated electromechanical systems. The MEMS program addresses issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. The microfluidic molecular systems program will address issues centered around the development of automated microsystems that integrate biochemical fluid handling capability along with electronics, opto-electronics and chip-based reaction and detection modules to perform tailored analysis sequences for monitoring of environmental conditions, health hazards, and physiological states.

(U) The MEMS program has three principal objectives: the realization of advanced devices and systems concepts; the development and insertion of MEMS products into DoD systems; and the creation of support and access technologies to catalyze a MEMS technology infrastructure. These three objectives cut across a number of focus application areas to create revolutionary military capabilities, make high-end functionality affordable to low-end systems, and extend the operational performance and lifetimes of existing weapons platforms. The major technical focus areas for the MEMS program are: 1) inertial measurement; 2) fluid sensing and control; 3) electromagnetic and optical beam steering; 4) mass data storage; 5) chemical reactions on chip; 6) electromechanical signal processing; 7) active structural control; 8) analytical instruments; and 9) distributed networks of sensors and actuators.

(U) Among the many accomplishments to date are: a wind-tunnel test of an integrated MEMS sensor and actuator array distributed along the leading edge of a model aircraft wing creating rolling moments of sufficient strength to control aircraft flight, pointing the way to future fighter aircraft with advanced maneuverability unattainable using conventional, large and discrete control surfaces; a demonstration of a MEMS-based accelerometer capable of surviving and operating in the near 100,000 G accelerations generated by firing artillery shells, making possible affordable guidance systems to what are presently unguided munitions and increasing both their effectiveness and life cycle costs; and the establishment of a regularly scheduled, shared, MEMS fabrication service for domestic DoD, commercial

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and academic users. The MEMS program has initiated new efforts in: low power miniaturized communications systems; distributed control aircraft roll and yaw; microscale power; micro airborne sensor/communication systems; data storage; and inertial systems.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Devices and Processes - Accelerated and expanded on MEMS system developments that exploit physics and MEMS systems architecture to project micro-scale actions into macro-scale effects such as micro-optomechanical scanners, switches, displays, adaptive optics and aligners. ($20.9M)
- System Design and Development - Extended present fabrication processes to cost-effective, large area fabrication approaches. ($22.6M)
- Support and Access Technologies - Integrated developments in MEMS, robotics and ultra-electronics to design, construct and field multiple, high-performance, mobile, autonomous systems. ($8.6M)
- Microfluidics - Initiated system-level integration through an evolving testbed strategy in which the development of new microfluidic components and processes occurred concurrently with the integration of early prototypes with available chip-based molecular analysis components. Leveraged analysis and detection technology from industry, Services, and other DoD programs when compatible with microsystems integration. ($17.3M)
- Continued efforts at Center for Advanced Microstructures Devices (CAMD). ($3.8M)

(U) FY 1999 Program:

- MEMS Devices and Processes - Demonstrate radio-frequency electromechanical signal processing; MEMS-based mass data storage; massively parallel read/write structures; micro thrusters for satellite attitude, propulsion and control. ($10.0M)
- MEMS System Design and Development, Phase I - Initiate concept demonstrations for systems in the form of aerodynamic control of model aircraft; low-power wireless integrated microsensors; miniaturized foresites for fuze, safe, and army. ($25.5M)
- MEMS Systems Design and Development, Phase II - Initiate concept demonstrations for microsensors for structural health, maintenance, and monitoring; gas-phase microinstruments; polymer-based MEMS; micro power sources. ($20.0M)
- Microfluidics - Demonstrate a microfluidic sensor system capable of indicating specific DNA hybridization events. Demonstrate detection of pathogens or protein molecules without requiring reporters by using coated

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beads and DEP/FFF/IS (dioelectrophoresis-field flow fractionation-impedance sensor). Demonstrate prototype microfluidic system to reconstitute a 20 ml volume of lyophilized material in 1 minute to 5% reconstitution accuracy using thermocapillary pumping and mixing. ($10.0M)

- Microfluidics - Demonstrate automated isothermal DNA analyzer: multichannel, multi analyte microchip device with integrated aerosol collector. Demonstrate portable biodetector prototype with sensitivity for 3 types each of bacteria, viruses and toxins as well as sensitivity to unknown toxicants by cell or coated beads. ($6.0M)

(U) FY 2000 Program:

- MEMS Insertions - Merge sensing, computing and actuating to realize new systems and strategies. These new approaches will bring new perception and control functions to weapons and battlefield environments. Program is in its third phase, systems demonstrations and insertion, including: Microassembled electromechanical signal processing; MEMS aerodynamic pressure sensors on flexible, adhesive tape substrate; Modular, monolithically integrated MEMS IMU; and MEMS high-temperature sensor and actuator arrays. ($29.3M)
- MEMS Integration/Devices and Processes - Develop new devices and processes for heterogeneous integration of MEMS, including micro power sources, micro processor units, micro actuators, and communication components. ($19.0M)
- MEMS Integration/System Design and Development - Initiate concept demonstrations for systems in the form of "smart dust," micro airborne sensor/communicator platforms, and chemically-powered remote sensors. ($18.0M)
- MEMS Integration/Support and Access Technologies - Initiate demonstrations of MEMS microassembly, packaging, and fabrication at distributed sites for robust sourcing of Integrated MEMS systems. ($12.7M)

(U) FY 2001 Program:

- MEMS Integration/Devices and Processes - Continue development of devices and processes for heterogeneous integration of MEMS, including micro power sources, micro processor units, micro actuators, and communication components. ($36.0M)
- MEMS Integration/System Design and Development - Perform concept demonstrations for systems in the form of "smart dust," micro airborne sensor/communicator platforms, and chemically-powered remote sensors. ($28.0M)
- MEMS Integration/Support and Access Technologies - Complete demonstrations of MEMS microassembly, packaging, and fabrication at distributed sites for robust sourcing of Integrated MEMS systems. ($16.0M)

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(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	73.2	71.5	72.3	50.0
Appropriated	73.3	N/A	N/A	N/A
Current Budget	73.2	71.5	79.0	80.0

(U) **Change Summary Explanation**:

FY 1998 Decrease reflects minor program repricing.
FY 2000 Increase reflects expansion to initiate MEMS integration.
FY 2001 Increase reflects initiation of major MEMS integration program.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Plan	Milestones
Jan 99	Demonstrate MEMS-based mass data storage.
Mar 99	Demonstrate MEMS control of delta wing model aircraft.
Mar 99	Demonstrate scanning probe arrays for mass data storage.
Jun 99	Demonstrate multi-frequency, tunable RF and microwave filters, switches, and phase shifters.
Jun 99	Demonstrate local micro-encapsulation of inertial instruments.
Sep 99	Demonstrate distributed, multiple, and miniature thrusters for satellite propulsion and attitude control.
Mar 00	Demonstrate microassembled electromechanical signal processing.
Jun 00	Demonstrate miniature aerodynamic pressure sensors on a flexible, adhesive tape.
Jun 00	Demonstrate a modular, monolithically integrated IMU.
Sep 00	Demonstrate MEMS high-temperature sensor and actuator arrays.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E						
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Mixed Technology Integration MT-15	0	0	36,000	71,205	53,510	50,000	50,000	50,000	Continuing	Continuing

(U) **Mission Description**: The goal of this Mixed-Technology Integration program is to leverage advanced microelectronics manufacturing infrastructure to produce mixed-technology microsystems that will revolutionize the way we see, hear, taste, smell, touch and control our environment at-a-distance, a paradigm that addresses many of the present and future needs of the DOD. These 'wrist watch-size', low-cost, lightweight and low power microsystems will improve the battlefield awareness and security of the warfighter and the operational performance of military platforms. At the present time, systems are fabricated by assembling a number of mixed-technology components: microelectronics, microelectromechanical systems (MEMS), microphotonics, microfluidics, and millimeterwave/microwave. Each technology usually requires a different level of integration, occupies a separate silicon chip and requires off-chip wiring, fastening and packaging to form a module. The chip assembly and packaging processes produce a high cost, high power, large volume and lower performance system. This program is focused on the monolithic integration mixed technologies to form batch-fabricated, mixed technology microsystems 'on-a-single-chip' or an integrated and interconnected 'stack-of-chips'.

(U) Microelectronics incorporates micrometer/nanometer scale integration and is the most highly integrated, low-cost and high-impact technology to date. Microelectronics technology has produced the microcomputer-chip that enabled or supported the revolutions in computers, networking and communication. This program extends the microelectronics paradigm to include the integration of heterogeneous or mixed technologies and thereby create a new class of 'match-book-size', highly integrated device and microsystem architectures. Examples of component-microsystems include low-power, small-volume, lightweight, microsensors, microrobots, and microcommunication systems that will improve and expand the performance of the warfighter, military platforms, munitions, and UAVs.

(U) The program includes the integration of mixed materials on generic substrates including glass, polymers and silicon. The program is design and process intensive, using 'standard' processes and developing new semiconductor-like processes and technologies that support the integration of mixed-technologies at the micrometer/nanometer scale. The program includes the development of micrometer/nanometer scale isolation, contacts, interconnects and 'multiple-chip-scale' packaging for electronic, mechanical, fluidic, photonic and rf/mmwave/microwave technologies. An example of a mixed-technology microsystem uses the integration of microfluidics, MEMS, microphotonics, microelectronics and microwaves to make a highly integrated, portable analytical instrument to monitor the battlefield environment, the physical condition of a warfighter, the identity of warfighters (friend or foe) or the combat readiness of equipment.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E, Project MT-15

The ability to integrate mixed technologies onto a single substrate will drive down the size, weight, volume and cost of weapon systems while increasing their performance and reliability. The resulting technology developments will make it possible to sense, compute, communicate, and effect the environment with small (match book-size), inexpensive components that can be deployed on ships, aircraft, combat vehicles, munitions and warfighters.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments: N/A

(U) FY 1999 Program: N/A

(U) FY 2000 Program:

- Process and Interconnect Technology Development and Verification. ($36.0M)
  - Develop 'through-the-chip' interconnects for electrical, mechanical, RF/microwave/millimeterwave, and microfluidic connectors.
  - Develop processes for 'through-the-chip' interconnects and isolation to stack a MEMS chip with a commercial CMOS integrated circuit chip using a 'stacked-chip' approach.
  - Demonstrate the reliability of a mechanical, through the chip interconnect.
  - Develop a technique to distribute optical signals 'through-the-chip'.
  - Develop processes for the integration of one compound semiconductor [GaAs, GN, GaAlAS, In P, etc.] in patterned areas on a silicon wafer.
  - Develop heterogeneous integration processes to form high quality, optically active materials (e.g. compound semiconductors, rare-earth doped oxides and glasses, ferro-electric thin films, etc.) on large area silicon substrates.
  - Develop processes and techniques for stacking three levels of silicon circuitry (CMOS active pixel array, A/D converters, processor). Demonstrate the use of flexible polymer interconnects for mixed-technology integration.
  - Develop mixed-technology models for processes and devices including stress models for stacking and bonding chips.
  - Develop models for electrical, mechanical, rf/microwave, micro-optical and microfluidic interconnects.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E, Project MT-15

(U) FY 2001 Program:

- Device Integration and Isolation Technology Development. ($71.2M)
  - Demonstrate an operating 50 GHz transistor using a compound semiconductor material in patterned areas on a silicon-chip.
  - Develop and demonstrate a stacked-chip that transfers millimeter wave signals between the chips described above and a second silicon-chip with passive millimeter wave components and through-the-chip millimeter wave interconnects.
  - Demonstrate electrical and mechanical interconnects between two, staked silicon chips.
  - Demonstrate the use of a microfluidic chip to cool stacked silicon microelectronics chips including 'through-the-chip' electrical and fluidic interconnects.
  - Demonstrate a MEMS sensor/actuator chip with integrated electronics on a second chip.
  - Demonstrate integrated silicon-based robotic elements for micrometer/nm-scale scale manipulation and probing.
  - Develop an integrated microphotonics, MEMS and microelectronics module for scanning and controlling light.
  - Demonstrate the fabrication of RF-photonic (e.g. low phase noise lasers, optical isolators, wide RF banwidth, high dynamic range optical modulators and detectors) components operating at RF frequencies of interest to military systems (1MHz - 100 GHz) heterogeneously integrated with low loss optical waveguides on silicon substrates.
  - Develop processes for the integration of microactuators, an energy source, and microelectronics to realize a batch fabricated, centimeter-scale silicon robot.

(U) FY 2002 Program: N/A

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	0	0	0	0
Appropriated	0	N/A	N/A	N/A
Current Budget	0	0	36.0	71.2

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies, PE 0603739E, Project MT-15

(U) **Change Summary Explanation**:

FY 2000-01 Increases reflect initiation of Mixed Technology Integration program.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: To be determined.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Maritime Technology; PE 0603746E, R-1 #44

COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Shipbuilding Technology MR-01	36,030	15,000	0	0	0	0	0	0	0	N/A

(U) **Mission Description:** The goal of the MARITECH Program is to preserve the U.S. shipbuilding industrial base by improving the industry's commercial competitiveness through advanced technology applications. For the Defense Department, a competitive shipbuilding industry optimizes Navy ship acquisition reform and allows realization of the Department's objective for affordable Navy ships. The goal of the DoD Acquisition Reform Program is to take advantage of the best commercial practices of industry and thereby achieve cost reductions of the ships and systems it purchases. Having operated exclusively in a protected domestic market, the U.S. shipbuilding industry has not implemented the best commercial processes necessary to compete in the international arena or to build affordable Navy ships. The government's attempt at acquisition reform, as it applies to ship acquisition, could fall short if U.S. shipyards are not commercially competitive. The key for acquisition reform is for the U.S. shipbuilding industry to attain global commercial competitiveness.

(U) MARITECH is a two-phased program that provides products and infrastructure for the near and long term. The near term effort enhances international competitiveness through the development of a portfolio of U.S. ship designs for the international marketplace and the build strategies for their competitive price and delivery. This effort is being enhanced by developing an infrastructure that includes the implementation of electronic communications and commerce throughout the industry, and by participating in an industry-wide forum for problem solving on a technical level.

(U) The long term effort includes the infusion of innovative product technologies and process improvements that brings the capabilities of the U.S. shipbuilding industry above those of foreign shipyards. This will result in a larger share of the international market, and a self-sustaining, highly efficient U.S. shipbuilding industry.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Completed Total Process Systems development projects initiated in FY 1997. ($8.7M)
- Completed Advanced Business Practices development projects initiated in FY 1997. ($13.1M)
- Completed development of standard data exchange translators for digital ship design and construction. ($3.8M)
- Completed advanced technology development projects initiated in FY 1996. ($4.3M)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Maritime Technology, PE 0603746E, Project MR-01

- Completed Electronic Commerce and Computer Integrated Enterprise project commenced in FY 1996. ($3.7M)
- Developed and initiated a long range national level, technology development strategy with National Shipbuilding Consortium. ($1.7M)
- Continued to improve and provide support for National Shipbuilding Network (NSnet). ($.4M)
- Initiated Commercial Cruise Ship Study. ($.3M)

(U) FY 1999 Program:

- Initiate research projects in the following areas: Advanced Ship Production Processes; Advanced Product Design and Manufacturing Technologies; and Electronic Customer and Supplier Interaction. ($15.0M)

(U) FY 2000 Program: N/A

(U) FY 2001 Program: N/A

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	36.0	15.0	0	0
Appropriated	36.0	N/A	N/A	N/A
Current Budget	36.0	15.0	0	0

(U) **Change Summary Explanation**: N/A

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Plan	Milestones
Jun 98	Complete test and evaluation of System Life Cycle Support Infrastructure Demonstration Project.
Sep 98	Complete development and test of integrated Product Data Environment for Shipbuilding.
Sep 98	Complete final 6 ship designs for International Commercial marketplace.
Sep 98	Complete remaining 10 process and product technology development projects initiated in FY 1995.
Sep 98	Complete development of long range technology development strategy for US shipbuilding industry.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Maritime Technology, PE 0603746E, Project MR-01

Jan 99 Initiate research projects for shipbuilding technology development.
Jul 99 Complete development of National Shipbuilding Information Infrastructure Protocols.
Jul 99 Complete prototype demo and development of commercialization plan for next generation PC based system for Integrated Product and Process Development.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE May 1998		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Electric Vehicles PE 0603747E, R-1 #45					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Electric Vehicles EV-01	14,522	0	0	0	0	0	0	0	0	N/A

(U) **Mission Description**: Electric and hybrid electric drivetrains provide compelling advantages for future tactical and combat vehicles. Of particular importance is a 50-percent reduction in fuel consumption due to higher efficiency, improved acceleration and maneuverability due to immediate torque to the wheels or tracks, and dramatically reduced thermal and acoustic signatures when operating from on-board energy storage. Affordability is addressed through reduced logistics requirements and the dual use applications of these technologies.

(U) The DARPA Electric and Hybrid Vehicle Technology program is pursuing research, development, and demonstrations of technologies for electric and hybrid vehicles that address military missions, modernization, and cost mitigation. Established by Congress in FY 1993, the program has pursued technology development and prototype demonstrations that are essential for future military systems, enhancing national energy security, and facilitating compliance by the Armed Services with federal clean air legislation. DARPA uses a unique decentralized management approach working directly with seven regional consortia. These diverse consortia provide a minimum of 50% of the funding and cooperatively function to overcome the challenges of developing electric and hybrid vehicle technologies. Consortium participants include military laboratories and bases, state and local governments, large and small defense contractors, well-established and startup manufacturers of vehicles and components, electric and gas utilities, public interest groups, and universities. Military requirements and infrastructure are implemented within this program at minimal federal investment, leveraging significant funds.

(U) Technology development is focused on: High-specific power engine/generator sets, including multi-fuel capable, high efficiency, and low emissions turbines, diesels, and rotary engines; Power control devices, including high-performance power semiconductors, control algorithms, and circuit integration and packaging; Energy storage devices, including advanced batteries, rapid battery recharging, flywheels, and capacitors; electromechanical conversion, including alternating current and direct current power, and linear motors; and lightweight high-strength materials, including space-frames and composites. These dual-use electric drivetrain technologies are being demonstrated in both commercial and military chassis. The technologies are directly relevant and are coordinated with the DARPA Combat Hybrid Power Systems (CHPS) and Reconnaissance Surveillance and Targeting Vehicle programs (budgeted under PE 0603764E, LNW-01). The CHPS program is developing an integrated electric power system to provide both continuous and pulsed power to all of the subsystems on a combat vehicle including weapons, C3I, countermeasures as well as the electric drivetrain developed in this program.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Electric Vehicles, PE 0603747E, Project EV-01

(U) The program transitions to the Departments of Energy and Transportation in FY 1999. The Research and Special Programs Administration of DOT and the Advanced Heavy Vehicle Technologies Program of DOE have budgeted to continue the program.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Completed development and field testing of hybrid electric High Mobility Multi-Purpose Wheeled Vehicles (HMMWVs), M1113, and Bradley Fighting Vehicle. ($3.6M)
- Developed and tested additional medium and heavy duty hybrid electric vehicles. ($3.5M)
- Developed and tested turboalternator and other auxiliary power units for medium and heavy hybrid electric vehicles. ($2.4M)
- Further integrated and tested flywheel energy storage units with containment. ($1.5M)
- Developed and tested improved and reliable batteries and battery management systems. ($1.5M)
- Developed and tested improved drivetrain and other components of hybrid electric vehicles. ($2.0M)

(U) FY 1999 Program: N/A

(U) FY 2000 Program: N/A

(U) FY 2001 Program: N/A

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	14.5	0	0	0
Appropriated	14.5	N/A	N/A	N/A
Current Budget	14.5	0	0	0

(U) **Change Summary Explanation**: N/A

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Electric Vehicles, PE 0603747E, Project EV-01

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Plan	Milestones
May 98	Complete preliminary designs of turboalternators for hybrid electric vehicles.
Sep 98	Complete demonstration of hybrid electric propulsion of second High Mobility Multi-purpose Wheeled Vehicle (HMMWV).
Oct 98	Complete field test of hybrid electric M113.
Dec 98	Complete testing of rapid charging units.
Dec 98	Complete field test of hybrid electric HMMWV.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communication Systems, PE 0603760E, R-1 #50

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Command, Control and Communication Systems	**150,010**	**200,100**	**224,886**	**214,578**	**224,583**	**222,583**	**225,583**	**225,583**	**Continuing**	**Continuing**
Command & Control Information Systems CCC-01	64,125	81,200	109,446	106,034	106,734	105,034	107,034	108,034	Continuing	Continuing
Information Integration Systems CCC-02	85,885	118,900	115,440	108,544	117,849	117,549	118,549	117,549	Continuing	Continuing

(U) **Mission Description**: This program element is budgeted in the Advanced Technology Development Budget Activity because its purpose is to demonstrate and evaluate advanced information systems research and development concepts.

(U) The Command and Control Information Systems Project is developing the technologies necessary to facilitate joint campaign planning and control throughout the battlespace. The primary program in this project is the Joint Forces Air Component Command System (JFACC), which will revolutionize command and control of joint and coalition air forces through the incremental development, integration, evaluation, demonstration, and transition of technology and systems. Other programs addressed in this project includes: the Integrated Battlespace program, Information Assurance program, the Advanced ISR Management program, the Advanced Joint Planning (AJP) advanced concept technology demonstration, the Agent-Based Systems program, Project Genoa, Counter Trans National Threat program and the Commercial Awareness Initiative program.

(U) The Information Integration Systems project will develop the technologies necessary to ensure that the enhanced information required by battlefield combatants is available on a near real time basis. Programs addressed in this project include the Dynamic Multi-User Information Fusion (DMIF) program, the Dynamic Database (DDB) program, the Battlefield Awareness and Data Dissemination (BADD), Advanced Concept Technology Demonstration (ACTD), the Airborne Communications Node (ACN) program, the Command Post of the Future program, and Course of Action Analysis program.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Command, Control and Communications Systems, PE 0603760E					
COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Command Control Information Systems CCC-01	64,125	81,200	109,446	106,034	106,734	105,034	107,034	108,034	Continuing	Continuing

(U) **Mission Description**: Recent military operations, e.g., Desert Storm and Haiti, demonstrated that current theater command, control, communications, intelligence/information systems, planning and rehearsal systems; and non-lethal weapon's capabilities lack the ability to support effective operations in diverse new arenas and scenarios ranging from desert heavy battle actions to urban areas with large civilian populations. Current capabilities do not provide real-time situational awareness, decentralized battle planning, rehearsal and execution capability, flexible interfaces or critical interoperable wide-area communications. The goals of the programs in this project are to build on an innovative architecture and infrastructure to enhance information processing, dissemination and presentation capabilities for the Commander by inclusion of information pertaining to enemy and friendly forces, providing a joint situational awareness picture and improving planning, decision-making and execution support capability and providing multimedia information interfaces and software to "on-the-move users". Integration of collection management, planning and battlefield awareness programs is an essential element of our strategy for achieving battlefield dominance through information systems.

(U) The Joint Forces Air Component Commander (JFACC) Program seeks to revolutionize command and control (C2) of joint and coalition air forces through the incremental development, integration, evaluation, demonstration and transition to the Warfighter of technology and systems which will enable new operational concepts for planning and execution that will significantly improve the responsiveness, efficiency and effectiveness of air operations. Key aspects of the program are: continuous near-real-time planning and execution with all tasks tied to a central strategy and embodied in a common plan representation; collaboration among distributed elements to achieve a high degree of integration through the echelons and across operations, intelligence and logistics; and end-to-end management of C2 operations including advanced capabilities for strategy development, target systems analysis, campaign assessment and resource planning. Key technologies include: centrally managed, multi-stage, concurrent plan generation; planning agents; intelligent resource scheduling techniques; dynamic resource reallocation algorithms; adaptive cueing tools; automated information routers; information tailoring and visualization tools and advanced collaborative and workflow management tools. These technologies will be applied to requirements that include: continuous mission planning processes that quickly anticipate and react to changes in guidance, threat

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situation, resource availability and synchronization needs; full integration of intelligence, logistics and operational activities to support strike operations and prioritized target nomination, information gathering and logistics support functions of the component commander; empowerment of cross functional planning teams to quickly respond to changes; and proper battlefield knowledge to support activities and decisions at multiple echelons. JFACC technologies, that support operational level decision making and information processing, will be interoperable with related DARPA and Service programs (e.g., Advanced Logistics Project (ALP), Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM), and Battlefield Awareness and Data Dissemination (BADD)). Program execution features a multi-phased, develop-demonstrate-transition approach, including close coordination with the Air Force and Navy Battlelabs, the Advanced Information Technology Services (AITS) Joint Program Office (JPO), and other service C2 organizations.

(U) The Integrated Battle Force Management (IBFM) Program will extend emerging information technologies and develop new methods to integrate joint force planning tools and operations management software applications. IBFM focuses on extending capabilities across service components (e.g., air, land, maritime) as well as between functional components (e.g., intelligence, operations, logistics, command-and-control warfare). The program will leverage technology from the JFACC program, Advanced Logistics, Planning and Decision Aids, and Genoa to coordinate and synchronize joint operations. IBFM will develop technology to support force allocation decision-making based on the CINC and Joint Task Force Commander's intent.

(U) With the growing dependence on information systems and the pressing need to be able to get the right information to the right person at the right time, it becomes critical to deliver and protect information and assure the availability of associated services -- particularly in a stressed environment. Information Assurance (IA) technologies will be integrated into future versions of the Defense Information Infrastructure (DII) Leading Edge Services (LES) to provide a robust architecture across a wide range of DoD information systems. The development and fielding of secure information systems will be a continuing process of development and upgrading of existing systems and capabilities. The program is developing and refining information security technology into the LES architecture and testbed. The resulting security framework will reduce information vulnerability, allow increased interoperability and functionality, and provide the operational commander greater assurance that he will have the information he needs when he needs it. The initial investment provides: near term applications to provide a modest level of protection and a mechanism to test advanced secure information development in an end to end environment.

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(U) The Advanced Joint Planning (AJP) ACTD was evaluated by US Atlantic Command (USACOM) and they determined that the AJP ACTD had "Military Utility" and is in the "leave behind" status. The Program Management was transitioned to the AITS JPO for the "leave behind".

(U) A new generation of collection systems will provide dramatically increased volumes of higher fidelity data to the operational decision maker. The challenge will be to dynamically manage and synchronize this advanced collection architecture with the next-generation processing, exploitation, and dissemination capabilities to provide the critical information to the decision maker in the constantly changing operational situation. The Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM) project will expand on efforts begun under the JFACC program and provide the technical foundation for ISR support to JV2010 through the development of Information Management, Collection Strategy Development, and Multi-asset Synchronization capabilities to dynamically optimize/synchronize, schedule, and task the spaceborne, airborne and ground based collection, processing, exploitation and dissemination architecture. The AIM project will optimize ISR support to precision engagement and dominant maneuver by providing proactive information support to the warfighter, continuous integration of Operations and ISR, responsive ISR timelines, optimal ISR confederation management, and synchronization of ISR asset and exploitation tasking. AIM's Information Management effort will insure near-real-time (NRT) information support to commanders and the Joint Task Force (JTF) by providing all echelons with: a common view of the collection environment; current status of collection, processing, exploitation, and dissemination operations; faster than real-time simulations in support of trade-off decisions; and the ability to conduct real-time multi-echelon coordination and shared decision making. AIM's Collection Strategy Development effort will interoperate with future automated operational plan representations to continuously interpret ISR requirements contained in the plan and decompose these requirements into discrete sensor, information retrieval, and exploitation tasks. AIM's Multi-Asset Synchronization effort will simultaneously plan and integrate platform routes and schedules that maximize the total information value from the ISR confederation in support of the operational plan. The AIM project will develop or advance technologies in the following areas: workflow management, multi-node collaboration, social computation, automated reasoning, mathematical programming, and cognitive representations. Resulting AIM capabilities will transition to DoD automated planning and C4ISR migration systems as appropriate.

(U) The Control of Agent-Based Systems Program will develop control strategies that enable intelligent assistants for warfighters allowing them to delegate tasks such as information gathering, logistics supply, and operations planning that can be automated, but currently overload military personnel. Unlike other software, agents reduce the user's workload by operating autonomously and using available information to make intelligent decisions on behalf of the user. Agents are cost-effective; adaptive to new users, tasks, and computing environments; and collaborate with

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other agents on the network to solve problems. Commercial industry is rapidly adopting intelligent agent technology because it potentially lowers software development costs and automates user tasks. However, being autonomous, agents can misinterpret user requests, go out of control, consume system resources, destroy user confidence, and eliminate any advantage to developers. Systems of agents produced by different developers can interact in complex ways. The Agent-Based Systems Program will complement commercial investment by developing control strategies to ensure heterogenous agent systems work correctly and predictably in the evolving Defense Information Infrastructure.

(U) Project Genoa is developing tools and a system for collaborative crisis understanding and management for the national security community from the National Command Authority to Commanders of the Unified Commands. The growing transnational threats increase the need for early crisis discovery and mitigation. The earlier a crisis situation is discovered, identified and understood at the National Command Authority level, the easier it is to arrive at preemptive or mitigating strategies. The objectives are to: (1) decrease decision cycle time from days to hours by reducing the time it takes to go from detection of a problem to completion of a thorough briefing with actionable options for the decision maker; (2) increase number of situations that can be managed simultaneously by an order of magnitude because with the increasing number of potential crisis situations and reduced resources we must make analysts more efficient, cover more situations and provide more diverse options; and (3) reduce number of military deployments. The key enabling technologies are: knowledge discovery of critical information from unstructured multimedia sources; structured argumentation to capture and present reasoning from evidence to conclusion; and a comprehensive corporate memory which will enable comparison of critical information across situation, time, and organization. The current clients for the prototype system are Commander in Chief Pacific and Director Defense Intelligence Agency. This project was initiated and budgeted in Tactical Technology, Project TT-03, but as it has evolved, it is being transitioned to CCC-01 in FY 2000.

(U) The Counter Trans National Threat (C-TNT) program will provide a means to reduce the threats of terrorism, weapons of mass destruction (WMD) proliferation, narcotics trafficking, information warfare, organized crime, and economic espionage. By leveraging current force protection and civil protection efforts and by exploiting promising technologies the C-TNT program will provide the framework for establishing an interactive global information system that will provide increased detection, understanding, warning and countermeasures effectiveness against these threats. The information system will utilize high bandwidth multi-national information exchange strategies and will exploit collaborative technology from such projects as GENOA and CPoF.

(U) The purpose of the Commercial Awareness Initiative (CAI) program is to ensure that DARPA can derive the maximum benefit of commercial research and development in information technology. This initiative will proceed in two

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phases. First, an analysis of near-term trends will be performed to determine the rate of maturation for existing and newly developed technologies. This analysis will help determine whether current DARPA and related DoD information technology programs are making effective use of commercially available technology. Second, long term projections will be made to map out anticipated developments and capabilities by commercial developers. The projections will be evaluated against DoD information technology needs and desired capabilities to identify specific areas for DARPA and DoD technology development. The result will be the creation of an information technology investment strategy.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Demonstrated and evaluated the basic technology/application building blocks and system architecture for the JFACC Program (Phase 2). Initiated development of JFACC Phase 3 capabilities - an initial integrated campaign management and continuous planning and execution ability. Developed the combined benefit of operational systems analysis and campaign assessment leading to an increase in mission cost effectiveness by a factor of three. Developed and demonstrated common communication protocols and resource protection strategies for Agent-Based Systems. Demonstrated interoperability with several related ISO Programs and the DII/GCCS. ($31.3M)
- Developed concept of operations for Integrated Battlespace Management Program. ($3.0M)
- Demonstrated Information Assurance (IA) automated capabilities to limit system access, and prevent system attacks by layering privacy security service over enclave-to-enclave protection and filtering out active code that is dangerous to enclave systems. Demonstrated gross responses for disabling attacks by shutting down outside connection and system-wide recovery. Demonstrated mechanism interoperability with negotiation protocols and good system administration tools to manage security mechanisms in DII LES. Integrated a basic Public Key Infrastructure certificate management system to support basic security services. ($20.0M)
- Awarded AIM development contracts for initial Measures of Military Utility, trade studies and trade-off analysis, and designed tools for information management, strategy development, and multi-asset synchronization. Conducted a Concept Validation demonstration of emerging multi-asset synchronization algorithms. Conducted an Integrated Feasibility Demonstration with loosely integrated components in a simulated environment. ($7.9M)
- Completed the transition and provide one year of maintenance support to the operational Advanced Joint Planning ACTD to USACOM. Conducted a formal assessment of the ACTD's functionality. Completed transition of selected components to the current DII COE version via the AITS JPO. ($1.9M)

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(U) FY 1999 Program:

- Complete development, integrate and demonstrate, evaluate and initiate transition of JFACC Phase 3 capabilities to service battlelabs and the AITS JPO. Initiate development of JFACC Phase 4 capabilities - a robust, integrated campaign management and continuous planning and execution capability that achieves 70% of all responsiveness, resource efficiency, campaign effectiveness and process flexibility goals. ($37.1M)
- Demonstrate automated capabilities to limit system access, protect data, manage replication and recovery, provide advanced detection and response to intrusions, anti-flooding techniques, and reconstitute/ reconfigure information services to reflect dynamic operational priorities. Demonstrate capability to do integrated monitoring of network service data, detected intrusion status and configuration/reconfiguration and to manage allocation of components and resources dynamically to reconstitute critical functions that have been degraded. ($20.0M)
- Develop AIM tools for information management, strategy development, and multi-asset synchronization. Conduct data collections at Ulchi Focus Lens joint exercise to support technology development. Demonstrate integrated ISR and operations planning in DARPA Information Superiority Demonstration 99. ($10.0M)
- Develop and test cooperative, federated, and market-based control strategies for Agent-Based Systems to assist information gathering and enhance military planning capabilities. ($14.1M)

(U) FY 2000 Program:

- Demonstrate, evaluate and initiate transition of selected capabilities of the JFACC System to operational users. Develop final Campaign Management functional capability to include: demonstration of integrated strategy development, objective/systems analysis and campaign assessment capabilities in an MRC scenario. Develop final Continuous Planning and Execution functional capability to include: generation of a comprehensive campaign plan for an MRC scenario in hours and continuous dynamic execution management. ($24.4M)
- Develop and demonstrate a modular force combined arms execution command and control toolkit with the ability to integrate the modular capabilities of schedulers, strike execution tools, Information Warfare planners, and maneuver controllers. Develop and demonstrate a specialized small unit synchronizing execution toolkit. ($14.0M)
- Demonstrate automated capabilities that enable dynamic, secure collaboration between enclaves including data and invocation flow rules. Demonstrate real-time, finer-grained advanced attack detection and response at the application layer, operating system, and network infrastructure. Couple advanced attack detection capabilities with automated system security and administration tools to enhance integrated monitoring and control of network services, detected attack status, and system configuration. Dynamically and

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automatically manage allocation of components and resources to reconstitute critical functions that have been degraded. Demonstrate security policy interoperability between enclaves. ($25.0M)

- Demonstrate AIM automated collection strategy development and continuous multi-asset synchronization within the Integrated Collection Management (ICM) ACTD. ($10.0M)
- Develop an enhanced agent communication language, an agent programming methodology and component libraries. Identify standard, protective agent services. Integrate compatible models of agent behavior. Demonstrate and stress-test in a military exercise 5-fold speed-up to plan and execute a time-critical operation. For commanders critical information items, demonstrate automated tracking and notification with 95% reliability with less than 5% false alarm rate. ($18.2M)
- In Project Genoa under knowledge discovery develop and implement information extraction from text and extensive use of intelligent agents, in structured argumentation refine crisis models and develop collaborative option generation, continue work on meeting transcription and develop ability to navigate and play back corporate memory. Implement products from Information Assurance project so that a multi-intranet system may operate at mixed security levels. ($10.0M)
- Counter Trans National Threat (C-TNT): Create preliminary information exchange architectures to allow integration of primary joint partners. Instantiate information fusion, assessment and alertment technologies from GENOA and CPoF. Perform a Concept Demonstration using currently available data streams. ($5.2M)
- Commercial Awareness Initiative (CAI): Assess the state of integration of commercial information technologies into DARPA and related DoD programs. ($2.6M)

(U) FY 2001 Program:

- Achieve comprehensive JFACC system integration and evaluation. Full functional capability of JFACC planning, execution and assessment system. Final transition to operational users. ($15.8M)
- Demonstrate CINC-to-tactical level integration of command and control capability with the enhanced combined arms execution toolkit with specialized small unit synchronizing execution toolkit integration to provide tailored force generation and command and control during execution at all echelons. ($18.0M)
- Develop automated scalable adaptive system security capability utilizing advanced attack detection indications and warning systems integrated with adaptive system monitoring and control. Develop security enabling technologies for autonomous software agents that allow agents to function safely across enclaves. Develop automatic security policy discovery and negotiation capability among enclaves. Develop information warfare indications and warning (I&W) tools, utilizing data fusion techniques, to provide Defense Information Infrastructure (DII) wide I&W capability. ($25.0M)

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- Conduct operational evaluation of AIM automated collection strategy development and predictive Indications and Warning. Transition collection strategy development technologies to the ICM ACTD. ($10.0M)
- Scale-up reliable agent systems. Develop and test methods for understanding large-system autonomous behavior. Demonstrate proof-of-concept prototype for self-configuring software applications comprised of network services and quantify utility for highly complex, dynamic command and control problems. ($20.1M)
- Incorporate changes resulting from client evaluation in real world environment. ($4.1M)
- Counter Trans National Threat (C-TNT): Incorporate select primary joint (multi-national) partner information systems into exchange architectures. Conduct the initial multi-national C-TNT demonstration. ($7.5M)
- Commercial Awareness Initiative (CAI): Project the far term commercial information technology areas and capabilities and identify DARPA/DoD-unique needs. Create a DARPA investment strategy to address those needs. ($5.5M)

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	64.1	81.2	88.6	106.0
Appropriated	62.5	N/A	N/A	N/A
Current Budget	64.1	81.2	109.4	106.0

(U) **Change Summary Explanation**:

FY 1998 Increase reflects expansion of Agent-Based Systems Program within JFACC Program.
FY 2000 In FY97-99 Project Genoa was funded in PE 0602702E, Project TT-03. It has been moved to CCC-01 for FY00 and beyond.

(U) **Other Program Funding Summary Cost**: N/A

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(U) **Schedule Profile**:

Plan	Milestones
Jun 98	Demonstrate JFACC Phase 2 - prototype JFACC planning and execution infrastructure/tools.
Jul 98	Integrate COTs security, security APIs, and detect intrusion tools in GCCS LES Release 3.x.
Aug 98	AIM Integrated Feasibility Demonstration of automated information need generation and decomposition.
Sep 98	AIM multi-asset synchronization participation in DARPA Information Superiority Demonstration (ISD) 98.
Sep 98	Demonstrate automated capabilities to limit system access, protect data, manage replication and recovery, detect and respond to intrusions, and reconstitute/reconfigure information services.
Dec 98	Detect 80% of IW attack set, disable attacks by shutting down outside connection and system-wide recovery by system rollback to condition prior to attack.
Jun 99	Demonstrate computer network resource protection for pathogenic agent systems.
Sep 99	Demonstrate JFACC Phase 3 - integrated campaign management and continuous planning and execution capability.
Sep 99	Integrate a basic Public Key Infrastructure certificate management system to support basic security services. Demonstrate basic replication techniques and anti-flooding techniques (port filtering).
Sep 99	Demonstrate integrated ISR and operations planning at Information Superiority Demonstration (ISD) 99.
Jun 00	Demonstrate collaboration in multi-agent systems developed without hard-coded interfaces.
Jun 00	Demonstrate AIM automated collection strategy development and continuous multi-asset planning within the Integrated Collection Management (ICM) ACTD.
Jul 00	Demonstrate modular combined arms execution toolkit and small unit synchronizing toolkit.
Jul 00	Demonstrate rapid knowledge discovery and structured argumentation in crisis management.
Sep 00	Demonstrate secure enclave-to-enclave collaboration. Demonstrate advanced intrusion detection and response capability integrated with dynamic system monitoring, control, and restoration.
Sep 00	Demonstrate and evaluate a robust integrated JFACC campaign management and continuous planning and execution system that demonstrates accomplishment of 70% of all responsiveness, resource efficiency, campaign and process flexibility goals.
Mar 01	CAI near-term technology implementation assessment.
Jun 01	Demonstrate agents that dynamically create software interfaces; define scalability limitations.

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Jul 01	Demonstrate CINC to tactical level integrated combined arms execution command and control with small unit synchronizing toolkit.
Jul 01	Demonstrate operational prototype crisis system functionality.
Sep 01	Demonstrate prototype adaptive security system and prototype DII I&W system.
Sep 01	Demonstrate a full functional capability JFACC planning, execution and assessment system which meets all goals.
Sep 01	Conduct operational evaluation of collection strategy development and predictive I&W.
May 02	CAI long-term technology development road map and investment strategy.
Jun 02	Demonstrate agent-based software technology for creating "super-applications" at run time.
Sep 02	C-TNT Initial Multi-national Demonstration.

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COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Information Integration Systems CCC-02	85,885	118,900	115,440	108,544	117,849	117,549	118,549	117,549	Continuing	Continuing

(U) **Mission Description:** The goals of the Information Integration Systems project are to take diverse inputs, including those planned as outputs from the PE 0603762E Sensors and Exploitation Systems project (SGT-04), and perform distributed and dynamic all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base, and through the use of wideband dissemination and integrated sensor management allow multi-site, real-time, collaborative situation assessment and course-of-action evaluations. These goals are being addressed by the Dynamic Multi-User Information Fusion (DMIF) program, the Dynamic Database (DDB) program, the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD), the Airborne Communications Node (ACN) program, and the Command Post of the Future (CPoF) program.

(U) The Dynamic Multi-User Information Fusion (DMIF) program is the premiere fusion advanced technology development program for the defense and intelligence communities, including next-generation automated capabilities to support the operational service fusion systems: All Source Analysis System (ASAS), Theater Battle Management Core System (TBMCS), and Global Command and Control System (GCCS). The program is developing and inserting a product line of fusion capabilities that combine information from multiple sensor-based sources (eg, IBS broadcasts, SAIP outputs, HUMINT reports, and NRTI SIGINT information) as well as outputs from multiple fusion engines (such as those resident within TBMCS, ASAS, the Common Ground Station (CGS), or Regional SIGINT Operations Centers (RSOCs)). Any given insertion of DMIF would combine, focus, and rectify information from these disparate sources to provide the joint warfighter with a clear and actionable picture of the battlespace. This DMIF-created picture will reduce information overload and overcome barriers to interoperability among sensor exploitation sites, intel processing sites, and operators' decision nodes. DMIF will strategically control the multiple fusion resources found at such sites in order to create real-time mission focused pictures of the battlespace (related to the Common Operational Picture). DMIF is also building a series of low-cost applications (Product Finishers) to provide "finished" situation information products to a wide variety of operations systems, including applications for targeting, Suppression of Enemy Air Defenses (SEAD), maneuver control, Battle Damage Assessment (BDA), and logistics planning. In all these efforts, a key DMIF program objective and measure of success is focused, rapid and effective transition of advanced fusion technology to warfighters via technology transition efforts already underway with GCCS, ASAS, and the DARPA-DISA Joint Program Office.

(U) The overarching goal of the Dynamic Database (DDB) program is to continuously produce significant battlespace information from immense quantities of multi-sensor data in a manner responsive to a diverse user community.

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More specifically, the DDB program will design, build, and demonstrate a system that (1) provides ready access to all battlespace sensor observations collected over time, (2) uses the resulting sensor history to identify and focus users' attention on tactically significant battlespace events, and (3) shares and synchronizes local situation changes across the distributed battlespace. Dynamic Database contents will be maintained and shared through a Dynamic Situation Model (DSM) that integrates geo-registered sensor history data with terrain, environmental, and force information to yield a logically consistent, multi-level view of the battlespace. Single and multi-sensor data fusion approaches will be developed that efficiently update the DSM by filtering tactically significant changes from the Dynamic Database sensor history. This objective includes the development of theory and techniques for incorporating mission and situation context into low-level processing algorithms, and advanced phenomenology models for translating expected conditions and behaviors into multi-sensor observables. Significant situation changes will be shared throughout the battlespace within a scaleable "DDB enterprise" of distributed DSM nodes, computing applications, processors, and information repositories. DDB enterprise technologies will be developed to monitor database conditions for change, trigger external processes when conditions meet posted criteria, propagate changes across DSM nodes, and support queries and searches of distributed databases.

(U) The objective of the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD) is to deliver, install and evaluate an operational prototype system that delivers to warfighters a consistent operational picture of the joint/coalition battlefield, allows commanders to design/tailor their own information environment, and provides access to key transmission mechanisms and worldwide data repositories. The description of the battlespace provided to the warfighters under this ACTD will be tailored to their mission needs by intelligent selection of information to be broadcast, intelligent processing of user requests (pull) and filtering at the warfighter workstation so that needed information is available. BADD will be evaluated through participation in exercises and demonstrations, and by insertion into ongoing pilot services, such as the Joint Broadcast Service installed in the European Theater in April 1996. BADD is also operating under a Memorandum of Agreement with the Global Broadcast Service Program Office to provide advanced information management capabilities and new applications for this system as part of the overall transition plan of BADD developments to operations after test and evaluation in the ACTD. Selected applications and dissemination services will be transitioned to the Defense Information Systems Agency (DISA) for incorporation into the Defense Information Infrastructure Common Operating Environment (DII/COE).

(U) The Airborne Communications Node (ACN) program will provide range extension and rapid deployment for many new and existing military communications systems. This is achieved through the placement of a highly flexible, software reprogrammable radio communication system on the Global Hawk High Altitude Endurance unmanned airborne platform. The ACN will connect isolated and rapidly maneuvering forces via high data rate communications, provide reach-back

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connectivity to CONUS from forward elements, and allow gateway connectivity among dissimilar radios. The Airborne Communications Node program will integrate Warfighter Internet functionality to provide PCS/cellular-like communication services (voice, data, broadcast, paging) to small handheld terminals. The program will conclude with field demonstrations in FY 2002.

(U) The objective of the Command Post of the Future (CPoF) program is to improve the speed and quality of command decisions while reducing the number of staff members required to process and manage the information systems required to do so. The approach is to provide a very intuitive, well integrated, decision-centered, information environment in which the commander and a few staff members can quickly understand the changing battlefield situation, select the best course of action (COA), communicate that COA to the implementing units, and monitor the execution. The key technologies to be developed are: (1) an integrated visualization environment where the commander and his staff can view immediately understandable presentations of the changing battlefield situation, presentations which are tailored to the situation and the command decisions of interest; (2) a powerful and comprehensive human-computer interaction capability (through speech and gesture understanding, language understanding, dialog management, and visual collaboration) so that the commander and his staff can successfully understand and explore the information environment, without requiring dozens of staff members to operate and integrate multiple information systems; (3) a command post dialog manager which would automatically track current activities and tasks in the command post to tailor the information presentations to topics of interest; (4) an integrated suite of knowledge bases, intelligent agents, plan sentinels, information processing assistants which would automate many of the lower level staff functions and automatically invoke and operate supporting, planning and analysis applications; and (5) a modular, portable suite of hardware and software components that can be quickly configured and tailored to various command environments (stationary and mobile), at different echelons of command.

(U) The Course of Action Analysis (COAA) program is focused on advanced technology development in the area of Course of Action Analysis. The program is developing a set of tools for performing COAA that can be demonstrated to determine the ability of these tools to support large-scale combat events. The COAA program will build upon the success of the FY 1997 and FY 1998 DARPA COAA technology program. Building upon this technology program, DARPA will expand the division level focus of the original program, to include: other Battlefield Operating Systems (BOSs); Corps level activities; integration with strategic planning tools; and incorporation during plan execution. In addition to expanding the operational application of COAA technology, the program will develop additional COAA techniques. These new techniques include advanced intelligent adversary, next-generation warfare (e.g., Information Operations, Special Unit Operations, and Low-Intensity Conflict), and COAA comparison techniques while exploring the applicability to other services. The ultimate goal of the COAA program is to provide an understanding of how to implement a robust Course of Action Development/Course of Action Analysis/Course of Action Execution toolset.

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(U) **Program Accomplishments and Plans**:

(U) FY 1998 Accomplishments:

- DMIF: Continued development of the DMIF system to implement an architecture for strategically controlled fusion which performs real-time context-sensitive tasking of multiple fusion engines. This tasking adapts to the characteristics of available or incoming information, the performance of the available information processing applications (such as ASAS, CIS, or GCCS), and the specific tactical situation (as represented by the commander's critical intelligence requirements or via automated planning systems). By selecting fusion engines and tuning their parameters based on the real-time context, strategic control of multiple fusion engines ensures that users get peak performance over a much broader range of conditions than any single fusion engine could provide. Systems include fusion engines from the Army, Air Force, Navy, national agencies, and R&D systems. Completed the first in a series of Product Finishers, including those supporting precision targeting, and integrating with operations applications that require real-time focused situational awareness. Demonstrated functionality at integrated operations/intelligence demonstrations with the JFACC program, the DARPA-DISA Joint Program Office, and transitioned components into ASAS. ($11.9M)
- Dynamic Database (DDB) Program: Completed the Phase I DDB architecture design. Installed the DDB Testbed to facilitate the exchange and evaluation of ideas and approaches, support distributed experimentation requirements, incubate and integrate evolving DDB technologies, and conduct system and technology proof-of-concept demonstrations. Laid the foundation for future DDB development by integrating existing "backbone" products (such as algorithms, phenomenology models, software, and databases) into the DDB Testbed. In conjunction with DMIF, produced an initial object schema for the Dynamic Situation Model. Initiated single and multi-sensor fusion algorithm research and demonstrate a prototype update service for the sensor history layer of the Dynamic Database. Produced initial geo-registration and mosaicing tools for SAR, MTI, IR, and ELINT sensor and incorporate tools in the Dynamic Database computation services. Developed a limited spatio-temporal database query capability. Produced an application programming interface specification for the Dynamic Database management system. Incorporated the initial Dynamic Situation Model object schema into the Dynamic Database and demonstrate the ability to ingest and process raw sensor data. Collected SAR, MTI, IR, EO, and ELINT sensor data in preparation for FY 1999 activities. ($16.0M)
- BADD ACTD: BADD is participating in and is being formally evaluated in an ACOM-conducted evaluation of the information dissemination management (IDM) programs first software release, increasing the level of automation previously provided to users and extending information management and dissemination support to the level of individual battalions/ships. BADD is providing new information management capabilities to include creation of a 3D graphical depiction of a consistent operational picture by near-real-time integration of all relevant databases, and identification and semi-automated resolution of differences

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building on DMIF technology. BADD is also standing up the first digital tactical video server and demonstrating real-time population of that server, as well as automated meta-data generation for a number of tactical video surveillance platforms. BADD is creating a CONUS Pilot Service for ACOM components and demonstrating and delivering an OCONUS Pilot Service tailored for the Pacific theater supporting the IDM program at DISA and the GBS Joint Program Office. ($43.7M)

- Airborne Communications Node (ACN): Selected multiple teams and initiated competitive ACN System Design and Technology Integration efforts. Continue Advanced Digital Receiver and RF MEMS Tunable Filters technology efforts. Initiate time varying magnetic flux antenna investigation. Initiated core technology integration and conducted initial technology demonstrations. The Warfighter's Internet Program has been integrated with the ACN Program and all reference to WI subsequent to FY 2000 will be under the ACN Program. ($11.1M)
- Command Post of the Future: The program focused on defining operational concepts for the new system and developing a concept demonstration to show operational users for evaluation and feedback. A group of operational advisors was formed from service representatives at the Army Battle Command Battle Lab - Ft. Leavenworth, the Mounted Maneuver Battle Lab at Ft. Knox, and the Marine Corp Warfighting Lab at Quantico. User studies were conducted by visiting operational military units to construct initial concepts of operation for CPOF, focusing on the Joint Land Forces Component Commander (JFLCC) as the target user. A concept demonstration was developed by integrating emerging technology in visualization, speech understanding, human-computer interaction, and decision aids to create an initial demonstration of envisioned CPOF capabilities. The demonstration will be presented to operational users for evaluation to further discuss and refine the operational concepts for CPOF. ($3.2M)

(U) FY 1999 Program:

- Continue the development of DMIF functionality. Move from static to dynamic strategic fusion control in order to react, in real time, to new information requirements from users. Move from pre-loaded to "agile" information models in order to incorporate, in battle-relevant timeframes, new knowledge about enemy forces and tactics. Add to the number of fusion engines (at least twelve systems) that are strategically controlled by DMIF, thereby both improving the performance of the confederated fusion engines and extending the interoperability of all systems which are associated with the encapsulated fusion engines. Add to the series of Product Finishers, including those supporting SEAD, JFACC, maneuver control, and IPB. Integrate selected DMIF services into broader environments that require entity-level fusion, specifically the Dynamic Database, GCCS, ASAS, and AITS, to create a product line of fusion systems that work flexibly and seamlessly

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with existing and emerging battlefield information systems. Complete integration and lab demo of DMIF II and demonstrate multi-service ops-intel interoperability with ASAS & AFATDS at an XVIII Airborne Corps operational exercise. ($8.0M)

- Complete a Phase II DDB architecture design that integrates DDB and DMIF technologies. Expand the Dynamic Situation Model object schema to include pedigrees that map entity-level situation assessments to multi-sensor source data. Develop and validate single-sensor terrain and entity phenomenology models. Develop prototype multi-sensor target phenomenology models. Elicit and incorporate situation context into single and multi-sensor anomaly detection algorithms. Demonstrate a prototype update service for the entity layer of the Dynamic Database. Extend database query services to include limited content-based index and query capabilities. Leverage existing COTS/GOTS technology to develop interactive tools for manipulating and visualizing Dynamic Database contents. Integrate technology products in the DDB Testbed and demonstrate an interactive prototype DDB system that ingests raw multi-sensor data, aligns and mosaics the data within a common 2-D spatio-temporal reference frame, identifies and cues the user to uncorrelated data features, updates the sensor history layer of the Dynamic Situation Model, and provides the user ready access to sensor history data. ($30.0M)
- BADD ACTD: [Transition]: Begin the 2-year ACTD sustainment phase. Operate Pilot Services and begin transition of initial CONUS and OCONUS Pilot Services to DISA. Complete the transition of integrated tactical video services to NIMA (video archiving tools) and to DISA/GCCS (video viewers). [Agile Information Control Environment (AICE)]: To avoid confusion the Phase III (Technology Improvement) part of BADD renamed to "Agile Information Control Environment." Under AICE continue developing technology enhancements and system capabilities as part of a technology improvement program separate from the ACTD. Examples of increased information management functionality include the creation and dissemination of the consistent operational picture by near-real-time integration of all relevant databases, and identification and automated management of differences using DMIF and DDB technology. Provide capabilities to perform resource management of multiple communication paths. Evaluate this capability via participation in a joint demonstration using Airborne Communications Node (ACN) technologies. AICE will begin investigating advanced technologies for extending information management services to support real-time mission-critical and life-critical applications and will pursue advanced models and tools for enabling commanders to create operations-based information management policies. ($47.9M)
- Airborne Communications Node (ACN): Select multiple system design teams and initiate payload design and development. Complete Advanced Digital Receiver technology development and integration. Continue RF MEMS Tunable Filter, programmable INFOSEC, advanced digital transmitter/external power amplifier and antenna technology developments. Continue ACN technology integration and demonstration. ($21.0M)

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- Command Post of the Future (CPoF): The program will begin to develop CPoF technology, an integration environment, and begin work to design a series of decision experiments to test the effectiveness of the CPoF system to improve command decisions. Technology development will begin to create new suite of human-systems interaction technology, the major technology emphasis of the program, to include work in cognitive engineering, displays and workspace design, visualization, multi-modal user interaction, and dialog management and reasoning. System integration will also begin to refine and integrate the individual technologies into a complete CPoF system for testing in simulation-based Command Post exercises. Experiment planning will begin with user representatives from the service battle labs to define operationally meaningful test problems and design a series of simulation-based decision experiments to test the effectiveness of the new technology in improving command decisions. The first version of an integrated CPoF system will be created and tested at the end of FY 1999. ($12.0M)

(U) FY 2000 Program:

- BADD ACTD: Complete the 2-year ACTD sustainment phase. ($7.5M)
- AICE: Continue development of advanced information management technologies including: Large-Scale Dynamic Channel Building Algorithms, Global Quality-of-Service Optimization, and Information Management Services to moving entities. Demonstrate prototype MetaNet providing end-to-end quality-of service across of DoD and commercial IP networks, as well as DoD tactical networks. Evaluate and select highest payoff technologies for insertion and evaluation within the BADD ACTD architecture. ($23.9M)
- Complete development of core DMIF functionality, including real-time dynamic strategic control of at least 12 existing fusion engines, using a combination of classical control theory, fuzzy logic, and resource constraint optimization. Perform quantitative assessments of the value-added of strategically-controlled information fusion, including reductions in total data elements presented to users, reductions in numbers of incorrect and out-of-date hypotheses and in location and identification errors. Performance comparisons will be made between a confederation of DMIF-controlled fusion engines and those same fusion engines operating stand-alone. Participate in a major training exercise (e.g., Ulchi Focus Lens) operating on live and simulated data from multiple sensors. All working DMIF code will be integrated into the Dynamic Database in order to enhance that program's early capabilities and to further develop advanced concepts initially explored under DMIF. More mature DMIF technology developed over the last five years will be transitioned to at least the DII COE and GCCS (DISA) and to ASAS (Army office of Program Management for Intelligence Fusion), providing Joint and Service capabilities for reducing information overload and improving interoperability for situation awareness. ($5.0M)
- Complete a Phase III DDB architecture design that prototypes a single node DDB testbed. Expand the Dynamic Situation Model object schema to include pedigrees that automatically map entity-level situation assessments

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to multi-sensor source data using data-driven fusion methodologies. Extract and fuse enhanced multisensor data features over time. Include visible EO into the stored data-types. Develop and validate multiple-sensor terrain and entity phenomenology models. Validate prototype multi-sensor target phenomenology. models. Incorporate automatic situation context into single and multi-sensor anomaly detection algorithms. Demonstrate an interactive prototype update service for the entity layer of the Dynamic Database. Extend database query services to include ad-hoc user requested content-based index and query capabilities. Leverage existing COTS/GOTS technology to update interactive tools for manipulating and visualizing Dynamic Database contents. Upgrade technology products in the DDB Testbed and demonstrate an interactive prototype DDB system that ingests raw multi-sensor data, aligns, mosaics, and displays the data within a common 3-D spatio-temporal reference frame, automatically identifies and cues the user to uncorrelated data features, updates the sensor history layer of the Dynamic Situation Model, and provides the user ready access to sensor history data and entity-level situation hypotheses. Incorporate DDB technology in XVIII Airborne Corps 525th Military Intelligence (MI) Brigade forward sensor enclave (FSE) testbed. ($30.0M)

- Command Post of the Future (CPoF). The program will produce new technology components, which will enable commanders to double the speed and quality of command decisions. Technology will be produced to enable the commander and his staff to easily access information and quickly understand changing battlefield situations by speaking, pointing and naturally interacting with a suite of high-resolution displays in a CPoF environment. Technology will be produced to automatically generate visual presentations of battlefield information, tailored to the individual commander's background, preferences, current situation, task, and topic of interest. Different versions of these technology components will be integrated and tested in a series of simulation-based decision experiments. ($18.0M).
- Continue the development of COAA functionality. New capabilities include extending the capability to Army Corps and Navy, technologies to develop clever adversary plans, demonstrate execution monitoring, and an initial approach to Course of Action Comparison. ($6.0M)
- Airborne Comms Node (ACN): Conduct manned aircraft demonstrations of competitive ACN system designs and select one team for final Global Hawk payload design and development. Complete final system design and begin system integration. Conduct laboratory demonstrations of critical subsystems. ($25.0M)

(U) FY 2001 Program:

- AICE: Demonstrate the capability to support real-time information flows across the MetaNet. Develop mechanisms for visualizing and understanding the macro structure of information flows supporting a large military operation. Automate the generation of information management policies based upon commanders intent. Assess military utility. Transition into the DII COE via the BADD Phase II architecture. ($24.7M)

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems, PE 0603760E, Project CCC-02

- Provide support for transition and hardening of DMIF systems transferred to DISA, Army, and other partner agencies. Exercise DMIF systems at multiple operational sites, and provide user-requested enhancements, fixes, and upgrades. ($1.1M)
- Complete a Phase IV DDB architecture design that prototypes and demonstrates an interactive 2-node DDB testbed. Expand the Dynamic Situation Model object schema to include pedigrees that automatically map force-level situation assessments to multi-sensor source data using data-driven & model-driven fusion methodologies. Include video data into the stored data-types. Extract and fuse visible EO to extend multisensor data features over time. Develop and validate EO & video terrain and entity phenomenology models to incorporate streaming video into the mosaic display process. Incorporate automatic access to all levels of situation context into single and multi-sensor anomaly detection algorithms. Demonstrate a fully interactive prototype update service for the entity layer of the Dynamic Database. Extend database query services to include rapid access to all levels of situation information in response to pre-defined user profile requested content-based index and query capabilities. Continue to leverage existing COTS/GOTS technology to update interactive tools for manipulating and visualizing Dynamic Database contents. Continue to upgrade technology products in the DDB Testbed and demonstrate an interactive prototype DDB system that ingests raw multi-sensor data, aligns, mosaics, and displays the data within a common 3-D spatio-temporal reference frame, automatically identifies and cues the user to uncorrelated data features, updates the sensor history layer of the Dynamic Situation Model, and provides the user ready access to sensor history data, entity- and force-level situation hypotheses. Incrementally update intelligent DDB services in 525th MI FSE testbed. ($30.0M)
- Command Post of the Future (CPoF). The program will continue to develop and integrate new CPoF technology into a complete CPoF system to enable commanders to double the speed and quality of command decisions. New versions of the technology components developed in FY 1999 will be integrated and tested in a series of simulation-based decision experiments. The most effective technology will be integrated into a complete CPOF system for an end-to-end demonstration of in a simulated joint exercise. Preparations will begin for an operational demonstration of the CPoF system in a joint field exercise in FY 2002. ($22.0M)
- Continue the development of COAA functionality. During this year the COAA program will participate in an Advanced Warfighter Experiment, extend the capabilities to COAA to the Air Force, explore the application of weak methods using limited domain knowledge, develop smart adversary capabilities in a multi-service domain, demonstrate an integrated mission planning/execution monitoring capability, and demonstrate an interactive mission debrief capability. ($6.0M)
- Airborne Comms Node (ACN): Complete system integration, conduct laboratory demonstrations, plan flight demonstrations with joint warfighters, and conduct Global Hawk flight demonstrations in a Joint Warfighter environment. ($24.7M)

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(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	85.9	118.9	98.8	100.2
Appropriated	89.4	N/A	N/A	N/A
Current Budget	85.9	118.9	115.4	108.5

(U) **Change Summary Explanation**:

FY 1998 Decrease reflects rephasing of BADD ACTD.
FY 2000 Increase reflects realignment to allow transition of AICE (Agile Information Control Environment) into DII COE via BADD ACTD phase II architecture.
FY 2001 Increase reflects reprogramming from PE 0603761E, Project CST-02 to the ACN (Airborne Communications Node) program for completion of payload integration and bench tests.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Plan	Milestones
Jun 98	Complete integration and lab demo of DMIF II and demonstrate interoperability with JFACC.
Jun 98	ACN Core Technology Final Design Review.
May 98	Complete ACN System Design/Technology Integration Study.
Jul 98	Deliver BADD battlefield awareness products for IDM EOC2.
Jul 98	Support operational exercise OCONUS (PACOM/Korea) and CONUS upgrade for BADD.
Sep 98	Complete prototype design of the Command Post of the Future.
Sep 98	Deliver BADD pilot service to OCONUS with DMIF baseline capability.
Sep 98	DMIF demonstration of focused situation awareness in joint-level simulation with JFACC, service and Agency migration systems (ASAS, DII COE).
Oct 98	Complete ACN Advanced Digital Receiver/Tunable Filters Brassboard and test.
Oct 98	DDB Phase I design complete; DDB Testbed installation complete; specification for sensory history database complete.

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Jun 99	Demonstrate single node prototype DDB sensor history database and computation services (registration and mosaicing) for SAR, IR, ELINT, and MTI.
Sep 99	Demonstrate technology enhancements to BADD capability (JWID '99).
Dec 99	Complete initial ACN System Design Reviews and conduct flight demonstrations of competitive ACN system designs.
Jan 00	Downselect to one ACN Team.
Mar 00	Participate in major field test experiment (Ulchi Focus Lens) operating on live and simulated data from multiple sensors.
Jun 00	Demonstrate an interactive DDB multi-sensor history database and entity-level situation assessment service (extending the services to include EO).
Jul 00	Demonstrate Smart Adversary to Army.
Aug 00	Complete DMIF transition to DISA, the Services, and DDB.
Sep 00	Demonstrate COAA techniques to Corps Operational, integrate with Strategic planning tools (i.e. ALP).
Sep 00	Complete BADD ACTD transition to DISA, GBS Joint Program Office (JPO) and the Services.
Sep 00	Demonstrate technology enhancements to BADD capability (JWID '00).
Sep 00	Complete Advanced Digital Receiver and RF MEMS Tunable Filters upgrades.
Oct 00	Phase III complete. Incorporate DDB technology into XVIII Airborne Corps 525th MI Brigade FSE Testbed.
Jun 01	Demonstrate multi-node DDB.
Jun 01	Demonstrate a fully interactive dual-node DDB entity- and force-level situation assessment service (extending the services to include video).
Jul 01	Demonstration of Smart Adversary extended to Navy and Air Force.
Aug 01	Complete ACN Payload Integration and Bench Test.
Sep 01	Demonstrate COAA level analysis within major Army exercise (e.g., Advanced Warfighter Experiment - AWE).
Oct 01	Phase IV complete. Incrementally update DDB technology into XVIII Airborne Corps 525th MI Brigade FSE Testbed.
Mar 02	Complete ACN payload integration and test with Global Hawk.
Aug 02	Complete ACN field demonstrations.
Sep 02	Complete ACN transition.

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APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE
RDT&E, Defensewide BA 3 Advanced Technology Development	Communication and Simulation Technology, PE 0603761E, R-1 #51

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Communication and Simulation Technology	**74,212**	**56,114**	**13,450**	**0**	**0**	**0**	**0**	**0**	**0**	**N/A**
Advanced Simulation CST-01	30,142	26,698	0	0	0	0	0	0	0	N/A
Global Grid Communications CST-02	41,302	27,916	13,450	0	0	0	0	0	0	N/A
Defense Simulation Internet CST-03	2,768	1,500	0	0	0	0	0	0	0	N/A

(U) **Mission Description**: This program element is budgeted in the Advanced Technology Development Budget Activity because it's purpose is to demonstrate and evaluate advanced simulation and networking technologies that will seamlessly integrate command and control functions needed for future global defense operations.

(U) The Advanced Simulation project is developing advanced simulation technologies that provide seamless synthetic battlespace that will enable high fidelity simulation across a full range of DoD functions. As technologies mature, they are integrated, tested and demonstrated in exercise/demonstrations of varying size and complexity. Within this project, the Synthetic Theater of War (STOW) Advanced Concept Technology Demonstration (ACTD) program is developing advanced simulation technologies to provide a seamless synthetic battlespace to support joint training and mission rehearsal activities.

(U) The Global Grid Communications project is developing and demonstrating advanced networking technologies needed for global defense operations in the 21st century. Network services will be developed in order to support geographically dispersed staff for crisis management and to support warfighters in rapid deployment, highly mobile scenarios. The program requires the design, adaptation and development of new internetwork protocols. The three main efforts in this project are: (1) the Joint Task Force Advanced Technology Demonstration (JTF-ATD) of a rapid Commander Joint Task Force (CJTF) crisis response capability for a range of situations from multiple regional conflicts (MRCs) to operations other than war (OOTW) capable of being established and operational in days; (2) the Warfighter's Internet program which will develop and demonstrate a mobile wireless backbone communications network consisting of multiple airborne nodes which in turn connect to users and networks on the ground, on the ocean, and in

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 1998
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the air, and (3) the Broadband Information Technology (BIT) program which seeks to develop all-optical multiple wavelength transmission and networking technologies.

(U) The goal of the Defense Simulation Internet (DSI) program is to research, develop and test at scale (worldwide), a network infrastructure capable of enabling distributed, real-time, multi-media (video, voice, shared data and work spaces) simulation that will seamlessly integrate all simulation, modeling, command and control functions from early design to battle rehearsal enroute to the conflict. The DSI transitions to the Defense Information Systems Agency (DISA) Defense Information System Network (DISN) on a fully reimbursable basis at the end of FY 1999.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Communication and Simulation Technology, PE 0603761E					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Simulation CST-01	30,142	26,698	0	0	0	0	0	0	0	N/A

(U) **Mission Description**: The strategic environment in which the United States operates will require Joint Forces to operate across the full spectrum of conflict. At the same time, resources will continue to shrink, requiring the Department to search for the most cost effective means to perform the full spectrum of defense functions. To support the National Military Strategy, the Advanced Distributed Simulation (ADS) program is developing advanced simulation technologies that provide seamless synthetic battlespace that will enable high fidelity simulation for Joint/Service readiness training and mission rehearsal. As technologies mature, they are integrated, tested and demonstrated in exercises/demonstrations of varying size and complexity. Within the ADS Programs the Synthetic Theater of War (STOW) Advanced Concept Technology Demonstration (ACTD) program is developing advanced simulation technologies that provide a seamless synthetic battlespace to support joint training and mission rehearsal activities. STOW applied high fidelity, platform level simulation technologies across the full spectrum of conflict enabling evolutionary changes in how joint forces train and rehearse for operational missions. The ultimate goal is to develop mature simulation technologies capable of representing Joint Forces from the level of Operations Other Than War (OOTW) up to the Joint Task Force level of combat. Specific technology efforts being undertaken as part of STOW include: 1) Multiple simulation system interfaces to real world C4I systems; 2) Advanced Distributed Networking; 3) Initiation of DoD's High Level Architecture (HLA) within the simulation; 4) Advanced synthetic forces and environmental databases; and 5) Interoperability with the United Kingdom Synthetic Environment Program. These technologies are then transitioned to Service and joint simulation developers.

(U) The STOW prototype has supported the United States Atlantic Command (USACOM) JTF level exercise, Unified Endeavor 98-1 in October 1997, and will support subsequent USACOM exercises during FY 1998 and FY 1999. Operational experience in these entity based simulation events provides valuable lessons learned, documentation, software products and tools/applications to support DoD's emerging family of Joint Simulation Systems, e.g. JSIMS, WARSIM, NASM, JSIMS Maritime component.

(U) The existing Operational Simulation (OPSIM) Technology Program has been divided into two programs. The Advanced Simulation Technology Thrust (ASTT) builds on the STOW Program and develops advanced simulation technology supporting the next generation of DoD simulation systems. The goal of the ASTT program is to solve core simulation technology issues such as advanced synthetic environments modeling, multi-resolution modeling, and scaling. The ASTT program acts as a technology bridge to future DoD simulation developments such as the Joint Simulation System

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(JSIMS). The other element of the OPSIM program called Course of Action Analysis, integrates Advanced Distributed simulation and ASTT developed technologies into operational planning systems to provide course of action analysis for operational users.

(U) **Program Accomplishments and Plans**:

(U) FY 1998 Accomplishments:

- Based on lessons learned from Unified Endeavor 98-1 and USACOM revised operational requirements, improved the STOW prototype and provided operational demonstrations of an increased capability to the joint warfighter in support of USACOM and the services. This included enhancing the warfighter's capabilities to employ high fidelity, platform level simulations for a variety of missions, by improving technology, tools and applications. Integrated new/improved synthetic environments, synthetic forces, and networking technologies as well as products developed in conjunction with the United Kingdom's Synthetic Environment Program. Continued transition of STOW technologies to JSIMS and other DoD users. ($13.3M)
- Continued development of Advanced Simulation Technologies in the ASTT program to support JSIMS, WARSIM and other service simulations. Technology efforts included: Adaptive multi-skilled Synthetic Forces; scaleability to greater than 20,000 objects; distributed multi-cast data collection on large amounts of data; rapid generation of computer generated forces and alternative methods of Synthetic Force generation; single synthetic environments database abstraction to accommodate multiple simulation requirements; initial multi-resolution modeling techniques. ($11.9M)
- Continued to develop and demonstrate Course of Action Analysis (COAA) technology based on advanced simulation technology and related modeling techniques. Extended FY 1997 effort to provide a tightly coupled COA development/COA analysis environment that shortens the overall planning cycle by 50%. Evaluated: extension of COAA technology to other Services; next generation COAA analysis techniques (such as advanced adversarial reasoning); and the techniques necessary to tightly integrate the mission planning/mission rehearsal/mission execution monitoring end-to-end process as it applies to land combat. ($4.9M)

(U) FY 1999 Program:

- Continue to refine and demonstrate prototype technologies in support of USACOM and the services. Demonstrations will focus on the representation of a seamless land/sea/air warfighting synthetic environment with an ever increasing degree of realism, and C2 interfaces, to support Service and joint operational training and analyses while retaining the arbitration of battle outcomes at the platform level of

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resolution. Transition of technology, tools and applications will continue in support of the next generation of DoD simulations. ($13.8M)

- Continue to develop high risk Advanced Simulation Technologies required by, and in coordination with, JSIMS and other Service simulations (e.g. WARSIM) to meet their respective Full Operational Capability (FOC) requirements. Technology efforts will include: demonstrating advanced time management and filtering techniques required to support JTF level exercise; reducing the cost of generating realistic behaviors capable of goal-based reasoning for synthetic command entities; demonstrating advanced techniques capable of creating and maintaining a consistent environment that supports correlated operation of force-on-force simulation at multiple levels of resolution. Continue to transition all technologies to JSIMS, et al. ($12.9M)

(U) FY 2000 Program: N/A

(U) FY 2001 Program: N/A

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	30.1	26.7	0.0	0.0
Appropriated	27.2	N/A	N/A	N/A
Current Budget	30.1	26.7	0.0	0.0

(U) **Change Summary Explanation**:

FY 1998 Reflects repricing of Course of Action Analysis (COAA) prototype.

(U) **Other Program Funding Summary Cost**: N/A

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(U) **Schedule Profile**:

Plan	Milestones
Mar 98	Demonstrate the ability of battalion level Synthetic Command Forces to plan a course of action, replan and respond to unexpected OPFOR tactics.
Jul 98	Support USACOM mission objectives in future exercises. Integrate and evaluate technologies developed under the United Kingdom's Synthetic Environments Program. Utilize the STOW prototype to support the operational evaluation of technologies developed under the ACTD, ASTT and JSIMS programs.
Sep 98	Demonstrate ability for ADS network to support real-time transport of a .3 Gigabyte at 3k transactions per second.
Sep 99	Complete the development, integration and documentation of the STOW prototype. Complete final transition of STOW Technology to JSIMS/WARSIM/NASM/JSIMS MARITIME.
Sep 99	Transition ASTT simulation technologies to the JSIMS and the Service simulation developments.
Sep 99	Program completion and close out.

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COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Global Grid Communications CST-02	41,302	27,916	13,450	0	0	0	0	0	0	N/A

(U) **Mission Description:** This project develops and demonstrates advanced networking technologies needed for global defense operations in the 21st century. Network services will be developed in order to support geographically dispersed staff for crisis management and to support warfighters in rapid deployment, highly mobile scenarios. The program will demonstrate that information technologies can be integrated with both advanced optical, high performance networks and mobile, wireless tactical. This will provide multimedia information flows, efficient use of bandwidth, and minimal logistical requirements for warfighting, disaster relief, emergency medical support. The program requires the design, adaptation and development of new internetwork protocols.

(U) The goals of the Joint Task Force Advanced Technology Demonstration (JTF ATD) include development of a rapid Commander Joint Task Force (CJTF) crisis response capability for a range of situations from multiple regional conflicts (MRCs) to operations other than war (OOTW) capable of being established and operational in days; provide collaborative planning tools to enable the development of integrated, executable operations plans in hours; provide en route planning and execution management for the JTF staff; provide a software reference architecture that provides access to the defense information infrastructure (DII), links the national command authority (NCA), commander in chief (CINC), JTF and the components, and enables rapid tailoring of the operational environment; provide common servers and application suites; and finally, to migrate the capability to the DII by the end of FY 1999.

(U) The goal of a Warfighter's Internet is to expand open architecture and internetworking technologies into the mobile wireless domain to: provide a robust, automatically reconfigurable, internetworking capability; and, to support warfighters in rapid deployment and highly mobile scenarios. This will be accomplished as a joint effort with the Airborne Communications Node program and will enable a backbone communications network consisting of multiple airborne nodes which in turn connect to users and networks on the ground, on the ocean, and in the air. Provision for multimedia information flows, efficient use of bandwidth, and minimal logistical requirements are key objectives that require the design, adaptation and development of new network protocols for mobile, wireless battlefield networks. Technology development and demonstration will focus on networking technologies to integrate existing and developmental communication systems and networks using airborne nodes such as Global Hawk (Airborne Communications Node). A scalable internet will be demonstrated in conjunction with joint service exercises and advanced warfighting experiments.

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(U) The Broadband Information Technology (BIT) program seeks to develop all-optical multiple wavelength transmission and networking technologies. Specifically, this program has four goals: (1) a billion bit per second bandwidth on demand, independent of the analog and digital nature of the applications, (2) rapid, nearly transparent reconfiguration of network routing, (3) multiplexing of continuous transmission rates (bit rates from thousands of bit per second to billion of bits per second), and (4) transmission of analog and digital signals in a single fiber.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Broadband Information Technology project demonstrated multi-wavelength network management and control in local area testbeds. ($6.5M)
- Broadband Information Technology project demonstrated 40 billion bit per second cross-connect switching and 32 channel transceiver chip. ($10.0M)
- Continued analysis and report on economics of multi-wavelength network architecture and technology for local area optical networks. ($1.3M)
- Continued integration with advanced information technology services needed to extend the Joint Task Force (JTF) Infrastructure by providing "composable Advanced Information Technology (AIT) services" that supported the planning phase, the execution phase, and the dynamic replanning phase. Developed Java-compatible Object Web Tools for generic plan editing, and demonstrated persistent brief development tools, bandwidth adaptive object based distribution and sharing, and schema unified semantic interoperability of several applications. Supported the extension of the infrastructure, architecture, servers and applications across computing platform classes and to emerging and related programs within the DARPA C2 development environment with the "composable AIT services". Transitioned additional components to the current Defense Information Infrastructure Common Operating Environment version via the AITS JPO. ($17.7M)
- Completed design and development of first phase of mobile, wireless network software and protocols, self-organizing cross links, network and mobility management, security, application interfaces, signalling protocols and RF subsystem integration and engineering based on the DARPA-led, joint Service study that defined technical requirements and network systems architecture for a Warfighter's Internet/joint tactical internetwork. Integrated technology with the Airborne Communications Node payload. ($5.8M)

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(U) FY 1999 Program:

- Broadband Information Technology project will demonstrate full operations, multi-wavelength, experimental, system network including interoperability among testbeds distributed across several geographic domains. ($6.9M)
- Develop software applications and servers from the "composable AIT services", and expand the JTF reference architecture to include execution and dynamic replanning. Transition selected "composable AIT services" to the AITS JPO for future incorporation into the DII COE. Demonstrate rapid development of specialized plan viewers for multiple echelons. Develop distributed information logistics services for optimization of time-value of information delivery. Support the extension of the infrastructure, architecture, servers and applications across computing platform classes and to emerging and related programs within the DARPA C2 development environment using the "composable AIT services" model. Transition additional components to the current DII COE version via the AITS JPO. ($6.0M)
- Warfighter's Internet project will integrate technology with the Airborne Communications Node developments. In coordination with Airborne Communications Node, initiate test & demonstration of airborne cross links, wireless backbone using manned aircraft; continue to develop network protocols and integrate into commercial products; integrate legacy and emerging radios in mobile, wireless internet. Demonstrate increased warfighter capabilities as part of combined ACN demonstration in early FY 2000. ($15.0M)

(U) FY 2000 Program:

- Broadband Information Technology project will demonstrate ferroelectric liquid crystal optical switching at microsecond speed. ($4.5M)
- Warfighter's Internet project will demonstrate end-to-end architecture in coordination with the Airborne Communications Node program in project CCC-02, PE 63760E. ($8.9M)

(U) FY 2001 Program: N/A

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	41.3	27.9	28.3	29.5
Appropriated	43.0	N/A	N/A	N/A
Current Budget	41.3	27.9	13.5	0

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(U) **Change Summary Explanation**:

FY 1998 Decrease reflects rephasing of Warfighter's Internet.
FY 1999 Decrease reflects rebaselining of the JTF program, which is transitioning to the Services.
FY 2000-01 Decreases reflect transition of Defense Information Infrastructure Common Operating Environment (DII COE) to AITS JPO, and completion of the Broadband Information Technology and Warfighter's Internet programs.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Planned	Milestones
3Q FY98	Complete large-area demonstration of optical network and advanced network management.
4Q FY98	Demonstrate initial execution and dynamic replanning functionality based on "composable AIT services".
4Q FY98	Complete design and development of components for the mobile wireless network.
1Q FY99	Demonstrate joint tactical internetwork, network hardware and software proof of concept.
3Q FY99	Demonstrate 20 gigabit per second, multi-channel, multi-media, large-area network.
4Q FY99	Demonstrate advanced execution and dynamic replanning functionality and transition selected "composable AIT services" to AITS JPO.
4Q FY99	Field demonstration of mobile wireless network technologies coordinated with BADD, Extended Littoral Battlespace (ELB) and Small Unit Operations experiments.
1Q FY00	Field demonstration of mobile wireless network technologies end-to-end architecture coordinated with Airborne Communications Node.
4Q FY00	Field demonstration of mobile wireless network technologies end-to-end architecture coordinated with BADD, Extended Littoral Battlespace (ELB) and Small Unit Operations in advanced warfighting experiments.

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COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Defense Simulation Internet (DSI) CST-03	2,768	1,500	0	0	0	0	0	0	0	N/A

(U) **Mission Description:** The goal of the Defense Simulation Internet (DSI) program is to research, develop and test at scale (worldwide), a network infrastructure capable of enabling distributed, real-time, multi-media (video, voice, shared data and work spaces) simulation that will seamlessly integrate all simulation, modeling, command and control functions from early design to battle rehearsal enroute to the conflict. The DSI meets DoD security requirements by using a commercial-off-the-shelf (COTS) encryption device (INES). The communications needs of the distributed, real-time, multi-media modeling and simulation community cannot be met with any other available technology. Commercial vendors are pursuing some of the required technologies, but development is too slow and unfocused to accommodate the immediacy of the Department of Defense's simulation requirements. The DSI program provides focus for the commercial development of the technologies needed by the simulation community for distributed work environments worldwide. Over 100 nodes currently extend the DSI to each of the Services, most of the Commanders-in-Chief (CINCs), some of our allies and other Government affiliated sites. These locations constitute the network's user sites; they provide valuable feedback on the technologies and methodologies being pursued and critical capability for both ongoing and major modeling and simulation events. DSI provided real time infrastructure for the Synthetic Theater of War (STOW) 97.

(U) The DSI will complete the transition to the Defense Information Systems Agency (DISA) Defense Information Systems Network (DISN) to be operational on a fully reimbursable basis by the end of FY 1999. Between FY 1998 and FY 1999, it will be jointly managed by DISA and DARPA through the Advanced Information Technology Systems Joint Program Office. The transition of the DSI into the DISN provides affordability through consolidation of the costs required to operate multiple networks while continuing to support modeling and simulation requirements.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Transition management: Provided programmatic integration management and engineering support through the DARPA/DISA Advanced Information Technology Systems (AITS) Joint Program Office (ADJPO) to identify and evaluate advanced technology candidates, offer pilot services, and transition Leading Edge Services (LES) technology to DISA. ($2.8M)

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Communication and Simulation Technology, PE 0603761E, Project CST-03

(U) FY 1999 Program:

- Transition management: Provide programmatic integration management and engineering support through the DARPA/DISA Advanced Information Technology Systems (AITS) Joint Program Office (ADJPO) to identify and evaluate advanced technology candidates, offer pilot services, and transition LES technology to DISA. ($1.5M)

(U) FY 2000 Program: N/A

(U) FY 2001 Program: N/A

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	2.8	1.5	1.5	1.5
Appropriated	2.8	N/A	N/A	N/A
Current Budget	2.8	1.5	0	0

(U) **Change Summary Explanation**: N/A

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Plan	Milestones
Sep 98	Identify and evaluate advanced technology candidates to DISA.
Sep 99	Complete programmatic integration management and engineering support to ADJPO.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Sensor and Guidance Technology, PE 0603762E, R-1 #52

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Sensor and Guidance Technology	**167,184**	**213,154**	**231,197**	**213,893**	**228,086**	**257,082**	**248,096**	**258,296**	**Continuing**	**Continuing**
Guidance Technology SGT-01	36,668	36,872	16,766	22,731	22,633	35,764	36,764	39,764	Continuing	Continuing
Aerospace Surveillance Technology SGT-02	19,603	70,500	82,551	72,729	73,517	93,486	80,500	87,500	Continuing	Continuing
Air Defense Initiative SGT-03	20,906	33,050	50,210	27,180	32,460	35,000	38,000	38,200	Continuing	Continuing
Sensors & Exploitation Systems SGT-04	90,007	72,732	81,670	91,253	99,476	92,832	92,832	92,832	Continuing	Continuing

(U) **Mission Description:** The Sensors and Guidance Technology program element is budgeted in the Advanced Technology Development Budget Activity because it is developing the system oriented technologies necessary to enhance sensor and weapon system accuracy and capability to meet current and emerging threats. Four projects are funded in this program element: Guidance Technology, Aerospace Surveillance Technology, the Air Defense Initiative, and Sensors and Exploitation Systems.

(U) The Guidance Technology project is leveraging geolocation technologies to enhance the navigation and/or guidance packages of airborne platforms, ground vehicles and weapons. These improved systems will improve the accuracy and effectiveness of stand-off weapons, minimizing collateral damage while reducing the cost-per-kill.

(U) Aerospace Surveillance Technology programs are developing technologies to improve the accuracy and timeliness of surveillance systems in all weather, in hostile reception environments, and when necessary, in a covert manner. The six programs funded by this project exploit recent advances in multispectral target phenomenology, signal processing, high performance computing and micro-electronics technologies.

(U) The Air Defense Initiative is an on-going activity whose overall goal is to reduce the proliferating cruise missile threat and enhance the survivability of U.S. assets in the face of enemy electronic countermeasures.

(U) The objective of the Sensors and Exploitation Systems project is to provide the warrior with situational awareness and battlefield dominance by developing key sensor technologies; providing near-real-time exploitation of imagery data; and semi-automated target recognition and tracking.

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COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Guidance Technology SGT-01	36,668	36,872	16,766	22,731	22,633	35,764	36,764	39,764	Continuing	Continuing

(U) **Mission Description:** Fire-and-forget stand-off weapons need precise targeting information if critical fixed and mobile targets are to be eliminated effectively with minimal collateral damage and minimum cost-per-kill. This requires that: (1) military surveillance and targeting systems geolocate targets accurately in the same coordinate system in which the weapon system navigates; (2) the surveillance, targeting and weapon systems have precision navigation and guidance systems on-board; and (3) navigation and target location systems robustly operate day/night and in adverse weather. In addition, future systems designed to accomplish precision strike missions must be significantly more affordable. The achievement of these characteristics in an integrated system is the goal of this program. The Global Positioning System (GPS) Guidance Package (GGP) technologies funded in this project are applicable for both new or retrofit guidance/navigation packages for a variety of airborne platforms, ground vehicles, surface-to-surface standoff weapons and air-to-surface weapons. Additional thrusts are also included in this project to increase the robustness of precision GPS navigation; to increase the versatility of navigation systems applications by developing micro-electromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation (Advanced Tactical Targeting Technology Program).

(U) GGP tightly integrates a miniature GPS receiver and an all solid state, low cost, navigation-grade, interferometric fiber optic gyroscope (IFOG) based miniature inertial measurement unit (MIMU) with an advanced navigation computer into a low cost ($15,000), precision navigation system. GGP Phase I addressed the technology issues involved in: (1) miniaturizing navigation grade inertial measurement units (IMUs) into a compact, manufacturable configuration; and (2) developing a multi-channel-on-chip, high dynamics GPS receiver. A Memorandum of Agreement (MOA) has been signed and implemented to demonstrate a Phase 1 unit on an Army Fire Support Team Vehicle (FIST-V). Successful demonstrations were conducted at Redstone Arsenal in June 1995 using a M981 FIST-V. Successful demonstrations also were conducted on an F/A-18. These tests assessed the performance of tightly coupled systems in high dynamics and validated Phase 1 design scenarios. GGP Phase 2 requirements place more stressing demands on performance of MIMU components and call for further reductions in size, power and weight. An MOA has been signed with the Navy designating GGP Phase 2 as the Navy's Advanced Integrated Navigation and Control Package. Another MOA was signed with the Program Executive Officer, Tactical Missiles, Army Missile Command. Potential applications include the Multiple Launch Rocket System. A third Memorandum of Agreement (MOA) has been signed with the Program

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Executive Office, Ground Combat and Support Systems, Army Tank and Automotive Command. Potential application is the Bradley Fire Support Team Vehicle (BFIST-V).

(U) The Global Positioning Experiments (GPX) will improve GPS receiver robustness by increasing their ability to operate effectively in presence of enemy jamming or countermeasures. First, an all-in-view Miniature GPS Receiver (MGR) chipset will be upgraded to demonstrate precision GPS direct code acquisition by employing a very low power, greater than 10,000 correlator, fast acquisition integrated circuit and high performance clock. Operation with precision P(Y) GPS code signals increases the MGRs robustness to jamming. The second thrust will provide for the design, development, implementation and demonstration of a low cost, all digitally controlled GPS adaptive phased array receiver antenna. This type of antenna eliminates the need for coherent precision matched analog antenna components and antenna recalibration for stressing military environments. The third thrust is an airborne pseudolite demonstration.

(U) The Micro-Electromechanical Sensor Inertial Navigation System (MEMS INS) program will improve the silicon based, inertial sensors (gyros and accelerometers) developed in the MEMS technology program and integrate them with navigation software into a low power, small, light weight, low cost, tactical grade (1.0 degree per hour to 10 degrees per hour drift rate) INS. In addition to handheld applications, the MEMS INS will be generic for insertion/embedding into other military systems. MEMS INS Phase 1 will perform the following: (1) design and develop higher performance appropriate MEMS inertial gyroscope and accelerometer sensors, (2) select and refine foundries/foundry processes, (3) design the mechanical subsystem, and (4) select/refine the navigation software and perform INS simulations of the modeled sensors. Phase 2 will develop the MEMS inertial sensors brassboard, integrate them into a MEMS INS and demonstrate the brassboard in the field.

(U) The Advanced Tactical Targeting Technology (AT3) program will demonstrate a passive tactical targeting system for the lethal suppression of enemy air defenses (SEAD). Today's threat radar targeting systems employed for SEAD fail to provide the rapid and accurate emitter geolocation needed to replace dedicated anti-radiation missiles (ARM) with generic, shoot-to-coordinate, smart weapons (e.g., JDAM or JSOW). The targeting system must negate emitter shutdown tactics now employed to defeat ARM guidance and enable simplified ordnance inventories. Generation and distribution or near real-time (e.g., seconds) comprehensive, and highly precise location of threat radars to all theater combatant aircraft is required without deploying any extra, SEAD dedicated, emitter collecting platforms. AT3 will accomplish this by widely deploying emitter collection packages hosted on existing airborne platforms, including combatant aircraft. AT3 will integrate (fuse) in real-time the distributed multi-platform emitter collections using existing or planned tactical (narrowband) radios with advanced network management (data packets)

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and signal processing. Additionally, to achieve the necessary wide deployment, AT3 self contained collection packages must impose negligible burden on their airborne hosts and be available at affordable prices. Enabling technologies now in development at DARPA will be used, including highly agile digital receivers packaged in multichip modules (MCMs), highly precise tactical clocks, tightly coupled integrated GPS/INS packages and advanced highly dynamic data fusion network management capabilities. Critical system advancements are (1) generating the commonly registered, theater-wide absolute doppler corrections to collected data and (2) managing the extraordinarily dynamic real-time data network including individual user kinematics and a changing aggregate participating user population.

(U) The Autonomous Landing Guidance (ALG) Technology Reinvestment Project (TRP) follow-on operational assessment program will install and demonstrate a low-visibility, day-night, precision approach and landing capability that is compatible with Air Mobility Command (AMC) operational requirements. The program will leverage work accomplished under the DARPA ALG TRP. The system (94GHz radar, Forward Looking Infrared (FLIR), Head-Up Display (HUD)) developed under the ALG TRP will be installed in a USAF C-130H3.

(U) The Sub-Meter Navigation Grid project exploits GPS to provide a common battlefield, highly accurate, geolocation and timing infrastructure which enables integrated distributed cooperative surveillance, communications, precision targeting and weapon delivery. The Grid's components are: (a) Airborne and portable ground based grid reference transmit stations within the battlefield which provide meter level GPS augmented absolute navigation along with centimeter level local relative navigation; (b) User integrated miniature packages which supports sensors and weapons with local centimeter level navigational and submicro-second timing capability along with intrinsic communications for in-flight target updating and reassignment; and (c) A grid network manager for the dynamically created local grids and intra-grid communication between sensors and weapons. The Grid will improve surveillance and targeting accuracies and timeliness and enable new weapon system capabilities. It will: provide direct sensor to weapon capability; improve current GPS based weapon system accuracy; provide for in-flight retargeting via intrinsic GPS based communications link; and reduce the cost, while improving the performance, of weapon systems. Enabling technologies developed under the program are low power deeply integrated MEMS based INS/GPS/Communications; robust self organizing networks for dynamic resource management and allocation; an affordable carrier phase precision GPS for dynamic platforms.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Continued fabrication and began integration of GGP Phase 2 hardware and software. ($6.0M)

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- Designed circuits and power management techniques for the direct precision GPS code, low power, robust MGR. ($10.0M)
- Designed the GPS adaptive antenna array, signal processing and control functions for the MGR. ($8.9M)
- Demonstrated proof of concept MEMS devices. ($3.3M)
- Conducted Advanced Tactical Targeting Technology (AT3) design and development. ($7.8M)
- Completed ALG system installation on C-130H3, and conduct operational flight tests. ($0.7M)

(U) FY 1999 Program:

- Perform final integration and testing of GGP units; deliver eight units. ($5.1M)
- Fabricate and demonstrate the robust MGR. ($5.6M)
- Conduct final design reviews and complete integration of adaptive GPS receiver antenna and signal processing. ($4.9M)
- Iterate MEMS foundry inertial sensor fabrication and initiate preliminary sensor testing. ($9.3M)
- Complete AT3 design and conduct critical component demonstrations. ($8.8M)
- Begin AT3 brassboard fabrication. ($3.2M)

(U) FY 2000 Program:

- Continue demonstration and evaluation of the robust MGR. ($1.5M)
- Test and evaluate GGP Phase 2 units. ($2.0M)
- Refine and reevaluate elements of the pseudolite network. ($0.5M)
- Develop breadboard elements and software for the submeter navigation grid. ($1.7M)
- Complete MEMS integration with navigation software and demonstrate INS operation. ($7.0M)
- Complete AT3 brassboard fabrication and ground tests. ($4.1M)

(U) FY 2001 Program:

- Complete Government evaluation of the robust MGR. ($1.0M)
- Complete refinement and evaluation of elements of the pseudolite network. ($0.5M)
- Complete Government test and evaluation of GGP Phase 2 units. ($0.5M)
- Complete AT3 Flight Test. ($4.0M)
- Conduct laboratory demonstration of breadboard elements of the Sub-Meter Navigation Grid. ($10.7M)
- Complete demonstration of MEMS INS operation. ($6.0M)

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(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	36.7	36.9	36.8	33.7
Appropriated	31.5	N/A	N/A	N/A
Current Budget	36.7	36.9	16.8	22.7

(U) **Change Summary Explanation**:

FY 1998 Change reflects increased emphasis on the integration of GGP with current platforms.
FY 2000-01 Decreases reflect reprioritization of Agency requirements.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Plan	Milestones
May 98	Begin integration of hardware and software for GGP Phase 2 units.
May 98	Complete fabrication of the direct P(Y) code, low power MGR breadboard.
Jun 98	Begin design of the Advanced Tactical Targeting Technology (AT3).
Jun 98	Complete Autonomous Landing Guidance (ALG) system installation on C-130H.
Sep 98	Conduct preliminary design review of MEMS gyro/accelerometer.
Oct 98	Complete critical design reviews and begin fabrication of an adaptive GPS antenna array.
Nov 98	Complete preliminary design of the AT3.
Nov 98	Demonstrate full function, low power miniature GPS receiver breadboard.
Jan 99	Deliver brassboard MEMS gyros.
Jun 99	Deliver GGP units to the Government.
Aug 99	Complete AT3 critical component demonstrations and begin brassboard fabrication.
Sep 99	Deliver engineering model MEMS accelerometers.
Sep 99	Complete integration of an adaptive GPS antenna array.
Feb 00	Complete test and evaluation of GGP Phase 2 units.
May 00	Complete integrated demonstration of miniature GPS receiver and adaptive antenna.

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Jun 00	Complete AT3 brassboard fabrication and begin ground tests.
Jul 00	Complete development of submeter navigation grid critical component breadboards.
Sep 00	Complete AT3 ground tests.
Sep 00	Test and deliver brassboard MEMS inertial navigation system.
Sep 00	Conduct demo of Submeter Navigation Grid.
Feb 01	Complete demonstration of submeter navigation grid breadboards.
Feb 01	Initiate AT3 flight tests.
Mar 01	Complete Government evaluation of the robust MGR.
Sep 01	Complete AT3 flight tests.
Dec 01	Complete element fabrication of Submeter Navigation Grid.
Apr 02	Complete integration of Submeter Navigation Grid and conduct demonstration.

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COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Aerospace Surveillance Technologies SGT-02	19,603	70,500	82,551	72,729	73,517	93,486	80,500	87,500	Continuing	Continuing

(U) **Mission Description:** This project funds space and airborne sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness. Timely surveillance of enemy territory under all weather conditions is critical to providing our forces with the tactical information needed to succeed in future wars. This operational surveillance capability must continue to perform during enemy efforts to deny and deceive the sensor systems, and operate, at times, in a covert manner. This project will exploit recent advances in multispectral target phenomenology, signal processing, large constellation satellite architectures, low-power high-performance computing, and low-cost micro-electronics to develop advanced surveillance systems. Surveillance is not an end to itself but rather an enabler for force protection and precision strike. Therefore a key component of this program is the development of a comprehensive sensor-to-shooter architecture.

(U) The Millimeter Wave Targeting & Imaging System (MMWTIS) program will develop and demonstrate a targeting and imaging, single UAV platform with all weather, day/night medium altitude capability at millimeter wave (W band) frequencies. This system will use active and passive techniques to achieve high resolution targeting (low CEP) and imaging (1-3 m). This system shall be used for weapons targeting, high resolution imagery, and battle damage assessment. Aperture sizes to be developed depend on developed active/passive system concepts (SAR/illuminator/passive radiometer) operating from tactical or MAE UAV operational altitudes. This program will pursue advanced radar algorithms and sparse aperture concepts, and intelligent incorporation of miniaturized monolithic integrated circuit (MMIC), advanced W band power amplifier technology, radio frequency photonics technology and low power high performance computing.

(U) The DARPA Radio Frequency (RF) Tags Program will develop technology to allow airborne radars (both Moving Target Indication (MTI) and Synthetic Aperture Radar (SAR)) to communicate directly with ground devices for identification of friendly assets, to covertly communicate information from ground sensors to the platform, and to correct for errors in the radar-determined location of targets. It is envisioned that RF tags will greatly enhance the utility of airborne radar systems by aiding in the identification of unfriendly targets via the timely communication and fusion of unattended ground sensors (UGS) data with the radar picture. Tags will also help to identify friendly assets by adding a unique identification (ID) to their radar return that is fused to the radar picture. Airborne radars are also being considered for targeting stationary and moving targets. By combining a Global Positioning System (GPS) receiver with an RF tag, and using the tag to transmit the tag's geographic

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coordinates to the platform, the location of targets within a certain distance of the tag can be determined with great accuracy. While the immediate RF Tags Program goals are to enhance the utility of airborne radars, it is envisioned that there are significant space based radar applications of this technology. A key goal of the RF Tags Program is a system with very low probability of detection, intercept and exploitation that is secure against an adversary with detailed knowledge (except for crypto key information) and moderate technical capability. The objective of the DARPA RF Tags Program is to design and demonstrate three types of tags: an ID only tag, a low data rate tag (suitable for low data rate unattended ground sensors) and a high data rate tag (suitable for image transmission).

(U) The Adaptive Spectral Reconnaissance Program will develop a new generation of airborne reconnaissance systems based on spectrally adaptive imaging sensors. Because it is particularly suited to real time detection processing, spectral technology will enhance the ability to conduct directed wide area search for high value targets from both manned and unmanned airborne platforms without substantially increasing demands on communications infrastructure or ground based data analysts. This is done by transferring the hyperspectral exploitation requirement to an on board data processor. This program will, in conjunction with Army funding, develop a day/night system using both reflected sunlight and thermal infrared emissions. This system will be demonstrated on manned platform and an Unmanned Air Vehicle (UAV) platform.

(U) The Tactical Radar Program will develop a new generation of aerospace-based radars tailored to support theater military operations. The program's first goal is development of an aerospace-based Ground Moving Target Indicator (GMTI) capable of detecting mobile-missile launchers and other high value ground threats deep in denied territory, beyond line-of-sight of airborne air surveillance assets. This includes developing techniques to enable an aerospace-based radar to function in a mode of operation enabling simultaneous collection of both Synthetic Aperture Radar (SAR) imagery and GMTI data, at very high area rates, without performance degradation. The second goal is development of techniques to correlate discontinuous GMTI target tracks ($\geq$ 4 min track durations, with intervening gaps of $\leq$ 15 min) produced by aerospace-based radar. The third goal is development of techniques to exploit aerospace-based SAR imagery for near-real-time (NRT) derivation of high-precision geolocation estimates (_ 3 meter Total Location Error) for ground targets, using high-fidelity Digital Terrain Elevation Data (DTED Level-5) in conjunction with SAR imagery. The program will involve airborne demonstration of advanced sensor-in-the-loop targeting via tactical radar midcourse guidance of cruise missiles.

(U) The Discoverer II program (formerly STARLITE) seeks to prototype a constellation of low earth orbit High Resolution-Ground Moving Target Indicator (HR-GMTI)/SAR radar surveillance satellites to provide timely, near

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continuous, hi-resolution, monitoring of any theater, anytime, anywhere. To achieve such revisit rates will necessitate deploying a large (24 bird) constellation. That in turn will necessitate achieving a revolutionary reduction in satellite per-unit on-orbit costs ($75-$100M), if concept implementation is to be affordable. Therefore, in addition to attaining the tactical radar program's principal surveillance technical goals, other advances must be achieved before system development can be pursued with acceptable risk: 1) developing a low-cost, multi-mode (GMTI/SAR) space-qualified electronically scanned antenna, 2) developing low power Microelectromechanical Systems (MEMS) for scanning of radar modules (10x reduced power requirement), and 3) sparse band processing for data compression allowing on-ground processing with .5Gbps links, and Automatic Target Recognition (ATR) quality (.5m) range profiling. The proposed satellite system will also use an interferometric synthetic aperture radar (IFSAR) capability to produce high-accuracy digital terrain elevation data (DTED) to support both battlefield visualization (BV) and precision guided munitions (PGM) targeting (3m localization accuracy theater wide). Discoverer II is a joint effort with the National Reconnaissance Office (NRO) and U.S. Air Force.

(U) The Novel Antennas Program applies crossover technologies, leveraging major investments already made in photonics, antennas and space-time adaptive array processing with the latest advances in digital receivers and devices employing superconductivity, to produce small, light-weight systems with low power requirements that are capable of locating specific emitters in a dense interference environment.

(U) The Large Millimeter Wave Telescope (LMT) is a Congressionally mandated program to develop the largest (50 meter aperture) fully steerable millimeter wave radio telescope built to date. The design features a sophisticated laser metrology system to maintain precise alignment of the optics, and real time closed loop adaptive control actuator system to maintain a near-perfect parabolic surface at all pointing angles and under most environmental conditions.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- The Millimeter Wave Targeting & Imaging System (MMWTIS) Program - Completed greybeard panel review and program assessment which shifted program from Passive MMW to Millimeter Targeting and Imaging, increasing the overall program scope. Issued Solicitation, evaluating and awarding concept development and preliminary design contractor efforts. Initiated 94 GHz signature measurements and analysis. Initiated Raytheon W band targeting effort. Refined requirements and subsystem and technical specifications for transmitter and component technology. Refining 3D SAR algorithms. ($4.6M)

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- Radio Frequency (RF) Tags program - Performed analyses for multiple concepts of operation to include remote communications of sensor data from unattended ground sensors, data communications from Special Operations Forces (SOF), geo-registration of Synthetic Aperture Radar (SAR)/Moving Target Indicator (MTI) imagery, and communications of geolocation and other data between dispersed operating units. System design for each operational concept was conducted, and fabrication of brassboard RF tags, modifications to airborne SAR/MIT processors and ground stations were completed. Tests were performed with the Joint Surveillance Target Attack Radar System (JSTARS) to define an RF tag system architecture and functionality. Flight tests were conducted with SAR tag designs to demonstrate a SAR tag and to design signal and image processing software. Development was initiated for ID-only and data extraction tags to be tested with SAR and MTI platforms. A CONOPS/Requirements study was completed to establish the system CONOPS, utility, value added and requirements, and a study of radar platform characteristics was initiated to evaluate suggested platforms. ($5.0M)
- Adaptive Spectral Reconnaissance Program - Developed system concepts and sensor specifications. Prototype system (NVESD Twin Otter) in flight, collecting data. Coordinated concept verification data collections occurring with Air Force Research Lab, Naval Research SITAC, and Aerospace Corporation. Completed concept definition to include algorithm development, mission utility analysis, operational concept, sensor specification development, test plan preparation, and data analysis conduct. Established transition partners with Army (Aerial Recce Low/Aerial Common Sensor PM) in terms of outyear POM and validated developed requirement. Worked transition issues with Air Force UAV Battle Lab and Air Force Recce SPO. ($3.0M)
- Tactical Radar Program - Developed initial algorithms supporting aerospace-based ground moving target indication (GMTI) using low-cost, light-weight, multiple phase center/receive channel antenna and 548 Mbps CDL. Established feasibility of high-throughput, GMTI collection (>800 km2/sec collection rate, sustained over >6 min). Established feasibility of achieving <10 kph Minimum Detectable Velocity (MDV) for ground targets. Developed initial algorithms supporting GMTI collection performance while simultaneously collecting undergraded synthetic aperture radar (SAR) phase history data, in 3m resolution mode. Established feasibility of achieving discontinuous GMTI track correlation, and developed initial algorithms enabling GMTI target tracking. Conducted selective/limited GMTI data collection using existing airborne SAR platforms. ($4.1M)
- The Large Millimeter Wave Telescope (LMT) completed critical system design. Access to site was prepared with geological surveys performed for antenna placement and foundation specifications. Comprehensive environment measurement program initiated. Initiated panel design and prototype development. Laser metrology design initiated. ($2.9M)

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(U) FY 1999 Program:

- Millimeter Wave Targeting & Imaging System (MMWTIS) - Continue development, conduct laboratory demonstrations, and initiate field testing of W band targeting system. Finish development and integration of prototype tactical subsystem. Conduct integration of MTI/3D SAR system. Finalize compatible imaging system designs, issue RFP for, and begin integrated system development of competitive W band targeting systems. Complete millimeter wave target signature characterization. Continue technology risk reduction activities. Develop concept of operations. ($12.5M).
- Radio Frequency (RF) Tags program - Complete development and testing of ID-only RF Tags for use with SAR and MTI airborne radar platforms. Continue design of data extraction tags for low data rate communications applications. ($8.0M)
- Adaptive Spectral Reconnaissance program - Continue system development. Develop prototype system and demonstrate prototype system in a range of operational scenarios. Continue data collections with concept verification platform (Twin Otter). Refine algorithms. ($9.0M)
- Tactical Radar program - Use algorithm chain processor to demonstrate: 4kt MDV detection performance; high-throughput GMTI; GMTI target tracking capability; acceptable probability of detection/false alarm performance (.9Pd at track level with 4 min revisit); data based feasibility of simultaneous Ground Moving Target Indication/Synthetic Aperture Radar (GMTI/SAR) mode; ground moving target identification and characterization) Pclass of .95 vs .1 for JSTARS). Demonstrate ability to deconflict targets and track convoys using airborne collects, with 5-10 targets per cross range resolution cell. Demonstrate ability for real time automated track fusion of SAR and GMTI data to monitor targets birth to death including stops, and terrain masking (5 minute fallout), using airborne collections. Demonstrate real -time targeting of moving ground vehicles using high -resolution MTI ($12.0M)
- Discoverer II program - Develop detailed engineering designs, producibility data, and performance analysis substantiating technical feasibility and cost estimate of a space-qualified electronically scanned antenna, and undertake the design, fabrication and laboratory testing of a subscale brassboard prototype array (consisting of a reduced number of full-scale subarrays -- the number of which will be sufficient to represent scaled performance of a full-scale active ESA operating at full design specification). Demonstrate 3x resolution gain with sparse band at low SNR. Demonstrate reduction in revisit rate required via angular diversity on target. ($10.0M)
- Discoverer II program - Initiate detailed engineering designs of the satellite (radar payload and bus) and its connectivity to the ground segment.($8.0M)
- Discoverer II program - Chip-level design and fabrication of the single channel digital radar polyphase channelization. Design of slow and fast FFT and pulse compression modules ($3.0M)

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- The Novel antenna program completed critical system design. Hardware integrated and tested. Sparse aperture algorithms developed and initial validation completed. Several broadband antennas developed and tested. Wideband photonic link designed and demonstrated non-real-time system experiments performed in Boston. ($8.0M)

(U) FY 2000 Program:

- Millimeter Wave Targeting & Imaging System (MMWTIS) - Flight Demonstration of W band targeting and imaging system. Downselect to one contractor for complete system development. Finalize technology risk reduction activities. ($13.0M)
- Radio Frequency (RF) Tags program - Continue the development and testing of data extraction RF Tags for both low and high data rate applications with SAR and MTI radar platforms; Demonstrate multiple RF Tags in an operational exercise with both SAR and MTI airborne radar platforms. ($3.8M)
- Adaptive Spectral Reconnaissance Program - Complete prototype system demonstration and transition to service partners. ($4.0M).
- Discoverer II program - Environmentally test a subscale ESA test article to ensure performance in a space environment. ($20.0M)
- Discoverer II program - Complete designs of the satellite (radar payload and bus) and its connectivity to the ground segment. Conduct Critical Design Review (CDR) of demonstration system, and make final contractor downselect. Initiate procurement of long-lead items. ($25.7M)
- Discoverer II program - Continue development of high-resolution DTED geolocation concepts and their insertion into on-going precision guided munitions (PGM) programs. Extend existing exploitation programs in aided target recognition, automated tasking, and dynamic database development as they pertain to Discoverer II. Further refine signal processing and target tracking algorithms to enhance signal-to-clutter performance. ($5.0M)
- Discoverer II program - Full-up chip fabrication and two-channel demonstration of digital radar subsystem. ($1.0M)
- The Novel Antennas Program will continue development of a robust system. A series of tests will be performed to emulate real world interference environments. Array designs will be tested. Algorithms will be optimized and documented. A wideband link will be demonstrated in the field. ($10.1M)

(U) FY 2001 Program:

- Millimeter Wave Targeting & Imaging System (MMWTIS) - Transition W band targeting system to Services (Air Force/Army/Navy/Marines) Flight demonstration of combined W band targeting and imaging system. ($8.5M)

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- Perform system demonstrations of Spectral Reconnaissance technology in real-time. ($1.1M)
- Discoverer II program - Continue on-going signal processing and target tracking algorithm development. ($5.0M)
- Discoverer II program - Initiate ground infrastructure development. ($2.1M)
- Discoverer II program - Begin subsystem manufacturing and assembly of demonstration satellite (radar payload and bus). ($46.0M)
- Novel Antennas Program - The Novel Antenna Program will transmit technology to a ground based military system for real-time urban operations. Adjunct platforms will be pursued for technology transfer and system integration. ($10.0M)

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	19.6	70.5	89.5	91.5
Appropriated	24.5	N/A	N/A	N/A
Current Budget	19.6	70.5	82.6	72.7

(U) **Change Summary Explanation**:

FY 1998 Decrease reflects reprogramming of the Novel Antennas program to another program element and the deferral of the Eclipse program.

FY 2000-01 Decreases reflect repricing of Discoverer II program to meet MOA funding requirements, and reprioritization of Agency requirements.

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(U) **Other Program Funding Summary Cost**: *(In Millions)*

Passive Radar Tags

Source	FY 1998	FY 1999	FY 2000	FY 2001
DARO	1.0	-	-	-

Adaptive Spectral Reconnaissance

Source	FY 1998	FY 1999	FY 2000	FY 2001
DARO	4.0	-	-	-
Army	-	4.0	-	-

Discover II

Source	FY 1998	FY 1999	FY 2000	FY 2001
NRO	3.9	14.9	29.2	68.5
Air Force	14.0	14.9	29.2	54.2

(U) **Schedule Profile**:

Plan Milestones

Millimeter Wave Imaging System:

Jun 98 Award contracts for competing W band sensor concept and design development. Finalize critical technology elements.

Dec 98 Complete concept development, W band targeting lab demonstrations, initiate concept of operations development.

Feb 99 Complete 3D SAR algorithms and limited prototype tactical subsystem development (Raytheon). Finish 3D SAR flight test (Raytheon).

Apr 99 Finish ESA development (Raytheon).

Jun 99 Complete signature characterization, and competing concept and design development.

Jul 99 Issue integrated system RFP.

Oct 99 Begin integrated system development.

Dec 99 Finish integration of MTI/3D SAR and begin testing (Raytheon).

Sep 00 Flight demo W band targeting system (Raytheon), CDR competing integrated targeting/imaging system.

Dec 00 Downselect to one W band targeting and imaging system, continue development.

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Dec 01 Transition to services complete.

Radio Frequency (RF) Tags:
Apr 99 Complete Radar Platform Analysis.
Jun 99 Complete ID-only Tags, radar/processing modifications.
Jun 00 Develop and test data extraction RF Tags.
Jun 01 Demonstrate multiple RF Tags in an operational exercise.

Adaptive Spectral Reconnaissance:
May 98 Demonstrate prototype system.
May 98 Release RFP for system development.
Aug 98 Award system development contract.
Nov 99 Delivery of spectral system.

Tactical Radar:
May 98 Develop specifications for algorithm chain processor.
Aug 98 IOC for algorithm chain processor.
Sep 99 Demonstrate advanced GMTI performance using algorithm chain processor.
Sep 99 Demonstrate simultaneous GMTI/SAR performance using algorithm chain processor.
Sep 99 Demonstrate GMTI target tracking using algorithm chain processor.

Discoverer II:
May 98 Begin space-based radar system design study.
Dec 98 Initiate System design/integration/demonstration contracts.
Feb 99 Begin detailed design of full-scale ESA and build subscale ESA test article.
Jul 99 Interim review of radar design.
Jan 00 Interim review of radar/bus system design.
Dec 00 Complete ESA subscale test article environmental testing.
Jul 00 CDR: Downselect the design/integration/demonstration contractor.
Jan 01 Begin Demonstration System subsystem assembly.
Jan 02 Begin Demonstration System final integration.
Jul 02 Begin Demonstration System final testing.
Nov 02 Complete Demonstration Satellite #1/SLV integration.

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Jun 02 Launch Demonstration Satellite #1.
Dec 03 Launch Demonstration Satellite #2.

Adaptive Spectral Reconnaissance:
Jun 98 Complete concept design studies.
Jul 98 Issue RFP for prototype system build.
Sep 98 Award build contract for prototype system.
Feb 99 Complete concept verification flights.
Feb 00 Delivery of prototype tactical spectral system.
Dec 00 Complete testing of tactical spectral system.
May 00 Transition tactical spectral system to services.

Novel Antennas:
Apr 00 Final data collection.
Jul 00 Wideband link demonstration.
Sep 00 Transition.

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COST (In Millions)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Air Defense Initiative SGT-03	20,906	33,050	50,210	27,180	32,460	35,000	38,000	38,200	Continuing	Continuing

(U) **Mission Description:** This Project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats. These programs include the Synthetic Aperture Radar Electronic Counter-Countermeasures (SAR ECCM) Program, the Low-Cost Cruise Missile Defense (LCCMD) Program, and the Air Directed Surface-to-Air Missile (ADSAM) Program.

(U) The SAR ECCM Program will develop techniques to make U.S. Synthetic Aperture Radar (SAR) systems less vulnerable to intentional enemy jamming or deception. SAR systems have become one of the most widely used broad area surveillance systems. They are critically important to the development of battlespace awareness and their jamming and/or deception could seriously degrade U.S. warfighting capability. The SAR ECCM program will determine the military impact of various SAR jamming techniques and develop countermeasures against the highest priority threats.

(U) The Low Cost Cruise Missile Defense (LCCMD): This program employs emerging missile seeker technologies to provide cost effective approaches to defeat proliferated asymmetric airborne threats. These threats include cruise missiles, unmanned air vehicles capable of conducting surveillance or jamming operations, as well as slow, low-flying manned aircraft such as helicopters and fixed-wing aircraft capable of dispensing chemical or biological agents. Various seeker options will be investigated, focusing on the development of very low cost, highly capable seekers which can be integrated into a missile interceptor and deployed in large numbers.

(U) ADSAM: The purpose of this joint DARPA/AMCOM/USMC/AMRAAM program office project is to rapidly demonstrate enabling technologies and operational concepts to support the destruction of low flying, difficult to detect targets, such as cruise missiles. This project demonstrates the critical technologies required to destroy such difficult to detect targets beyond the line-of-sight and at the full intercept range of surface-to-air missile systems. This live fire demonstration program uses an elevated platform to provide target cueing and updates to Advanced Medium Range Air to Air Missiles (AMRAAM). These missiles are ground launched from modified High Mobility Multi-Purpose Wheeled Vehicles (HMMWV) developed by DARPA and AMCOM, known as the HUMRAAM. This demonstration program also supports the Marine's ongoing HUMRAAM program, called the Complimentary Low Altitude Weapons System (CLAWs), by allowing them to quickly progress from concept development through demonstration/validation in less than 1 year. Early successes with the HUMRAAM have led the Marines to include its further development and acquisition in their FY 2000 POM, and the Army to conduct two FY 1998 live fire tests.

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(U) **Program Accomplishments and Plans**

(U) FY 1998 Accomplishments:

- SAR ECCM: The study panel updated their analyses of intelligence, surveillance and reconnaissance (ISR) SAR ECM vulnerability and candidate ECCM technique performance. Data to support analysis and algorithm design was collected with a representative ISR SAR system supported by DARPA's Sensor Emulation Platform, (SEP) Program. ECCM techniques applicable to the SEP class of ISR radars were analyzed for performance versus implementation costs. ($5.7M)
- Low Cost Cruise Missile Defense (LCCMD): The concept development efforts initiated in FY 1997 were completed and a design effort initiated leading to the fabrication and flight test of a prototype seeker for the low cost missile. Additionally, three contractor teams were selected to begin the preliminary design and analysis for advanced low cost seekers to defeat an expanded array of asymmetric airborne threats. FY 1997 funding was budgeted under a different PE. ($10.4M)
- ADSAM: Two successful "dry runs" of the complete ADSAM architecture were conducted in 2nd QTR FY 1998. During the 3rd QTR two (2) "live fire" tests will be conducted in which two HUMRAAM missiles will destroy two simultaneously launched low-flying cruise missile targets. Upon successful completion of this demonstration, the residual assets (2 HUMRAAMs with associated hardware and software) will be dispositioned to the Marine Corps to support their ongoing Complimentary Low Altitude Weapons System (CLAWS) program. ($4.8M)

(U) FY 1999 Program:

- SAR ECCM: The hardware implementation of candidate SAR ECCM algorithms applicable to Sensor Emulation Platform (SEP) will commence. Selected ECCM techniques will be implemented for mitigating low-level ECM threats in both the analog (front end) and image domain portions of the radar. Additional data will be collected to support technique development. A laboratory demonstration of the selected ECCM products will occur. Design efforts and test planning will get underway in preparation for a proof of principle demonstration scheduled for FY 2000. ($8.1M)
- LCCMD: Design of the MLI interceptor will continue. The concept development and initial design and analysis development efforts for the best passive seekers begun in FY 1998 will be completed. Detailed design and fabrication of the Ka Band MEMS Electronically Steered Array (ESA) test articles will be complete. The noise correlation radar captive flight test system will be fabricated and aircraft integration will begin. ($25.0M)

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(U) FY 2000 Program:

- SAR ECCM. The design and implementation of the selected ECCM techniques will be completed and integrated on on-board the SEP. A proof-of-principle demonstration will be conducted with real-time in-flight jamming and processing. ($13.2M)
- LCCMD: The Noise Correlation Seeker will conduct Captive Flight Testing to test and demonstrate its low cost potential and robust performance against typical threat targets. Fabrication and testing will be conducted on the full MEMS, Ka band seeker, the MLI interceptor and two seekers that will be down-selected from the Low Cost Interceptor Seeker (LCIS) initial design and analysis task, begun in FY 1998. Seeker selection for live fire will be completed. Large, lightweight aperture testing will begin. ($37.0M)

(U) FY 2001 Program:

- SAR ECCM: A final operational real-time demonstration will be conducted with the modified SEP platform against a set of recognized and non-recognized ECM threats. The effectiveness of the DARPA developed ECCM techniques will be qualitatively evaluated by image analyst assessment of SAR image interpretability and quantitatively evaluated by using current state-of-the-art automatic target recognition (ATR) software. ($3.0M)
- LCCMD: Captive flight tests will be conducted to demonstrate both the Ka band MEMS seeker and the LCIS low cost potential and robust performance against typical threat targets. The most promising seeker will be integrated into the MLI airframe to support a FY 2002 live fire demonstration against representative threat targets. The lightweight fire control radars will be evaluated to select the most promising and capable design that will also support the FY 02 live fire demonstration. ($24.2M)

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	20.9	33.1	53.1	27.2
Appropriated	17.6	N/A	N/A	N/A
Current Budget	20.9	33.1	50.2	27.2

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(U) **Change Summary Explanation**:

FY 1998 Increase reflects requirement for additional LCCMD funding.
FY 2000 Decrease reflects realignment of program priorities.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Plan	Milestones
LCCMD:	
May 98	Advanced seeker BAA selection
Sep 98	Concept systems design review
Mar 99	Concept Preliminary design review
Sep 99	Noise correlation seeker integration
Jan 00	Noise correlation seeker flight tests
Jan 00	Ka band MEMS aperture testing
Aug 00	Live fire configuration selection
SAR ECCM:	
Aug 98	SEP data collection
Jan 99	Algorithm/Hardware Implementation
Aug 99	Laboratory ECCM Demo
Aug 00	Field ECCM Demo
ADSAM:	
Phase I (HUMRAAM):	
Jun 98	Live Fire Demos completed
Jun 98	Transition to USMC

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COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Sensor and Exploitation Systems SGT-04	90,007	72,732	81,670	91,253	99,476	92,832	92,832	92,832	Continuing	Continuing

(U) **Mission Description**: The development efforts described herein embody key sensor demonstrations and the exploitation of sensor products. These efforts, in conjunction with those described in Project CCC-02 (Information Integration Systems) seek to develop the systems needed to provide the warrior with situational awareness and battlefield dominance. The strategic goals of this project are to: develop key sensor technologies required to support dominant battlefield awareness, including sensors which can counter Camouflage, Concealment and Deception (CC&D); provide near-real-time, semi-automatic, exploitation of wide-area moderate (and high) resolution imagery; and provide semi-automated recognition and birth-to-death tracking of high value units and critical moving targets. These goals are being addressed by the Counter CC&D Program, the Semi-Automated Imagery Intelligence (IMINT) Processing (SAIP) Advanced Concept Technology Demonstration (ACTD), Continuous Ground Vehicle Tracking (CGVT), Sensor to Shooter to Weapon (SSW), Moving and Stationary Target Acquisition and Recognition (MSTAR), Moving Target Exploitation (MTE), Automatic Target Recognition (ATR) applications programs, and Airborne Video Surveillance (AVS).

(U) The goal of the Counter CC&D Program is to significantly enhance the military's capability to detect obscured targets hidden under natural and artificial camouflage. Specific goals include validation of Foliage Penetration (FOPEN) target detection capability (0.1 FA/sq.km max) using FOPEN Synthetic Aperture Radar (SAR). The FOPEN SAR will be developed for demonstration on a manned platform (Army RC-12) providing inputs via narrowband tactical data links for ground image exploitation. A Ground Control and Display Subsystem (GCDS) is being developed to provide real time, remote operation of the FOPEN SAR, Automatic Target Detection and Cueing (ATD/C), and a Common Imagery Ground/Surface System (CIGSS)-compliant exploitation interface. The image exploitation processing of SAIP will be extended for FOPEN as well as Multi/Hyper Spectral Image (M/HSI) sensor input, geolocation and sensor fusion processing of images, and detection of time critical targets. The program will ultimately combine FOPEN Radar on the Global Hawk High Altitude Endurance Unmanned Aerial Vehicle (HAE UAV) with other airborne sensors (e.g., the Senior Year Electro-optical Reconnaissance System on the U-2, and develop combined exploitation technologies for insertion into the CIGSS.

(U) The Semi-Automated IMINT Processing (SAIP) ACTD will develop, test and transition to the operational user, automated algorithms and semi-automated tools that enhance the warfighter's capability to: process SAR, and later EO imagery; conduct wide-area search for Ground Order of Battle and Missile Order of Battle targets; perform rapid site

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modeling and site monitoring; and produce target reports in near real-time (< five minutes). Goals for the baseline system are: automatic target cueing and classification for a limited set of vehicles (10 targets); object level change detection; force recognition to the company level; and interactive target recognition and terrain delimitation. Goals for an enhanced system are: increasing the automatic target cueing and classification to 20 targets; site modeling and monitoring with EO and SAR; and addition of SIGINT cueing. An enhanced fielded system will further increase automatic target recognition to 30 targets.

(U) The Continuous Ground Vehicle Tracking (CGVT) program will monitor the positions of military forces and vehicles regardless of terrain masking, stop-and-go behavior, and nearby traffic. CGVT will exploit multiple synthetic aperture radar and ground moving target indicator radars synergistically to maintain constant awareness of ground vehicles dispersed over a wide area and for an extended period of time. The following technologies will be developed to accomplish this goal: automatic target verification (ATV) employing ATR techniques with the added constraints available through continuous tracking; extended monitoring frameworks that combine moving target trackers with stationary target monitoring techniques; and dynamic resource management to collect the right data at the right time. The program will culminate in 2002 with an integrated demonstration of tracking 100 vehicles maneuvering within a 10,000 km^2 playbox over a 24-hour period.

(U) The goal of the Moving and Stationary Target Acquisition and Recognition (MSTAR) program is to achieve a major advance in Automatic Target Recognition (ATR) performance on SAR imagery through fundamental and innovative technology developments and to transition this technology to fielded systems with ATR requirements. The approach to detect stationary targets utilizes traditional ATR techniques to first determine suitable target candidates for image regions of interest (ROIs). A model-driven subsystem then refines these candidates by using a SAR signature prediction module to determine the true target ID of the ROI. To handle moving targets, one-dimensional model-based analysis of radar returns from multiple viewpoints will be used to perform identification. Other program goals include: significant advances in tools that include ATR capabilities to efficiently perform interactive image exploitation; development of rapid target model construction; collection and dissemination of high-quality databases of SAR signatures, development of resource management systems for surveillance and exploitation, and development and demonstration of ATR- and compression-based techniques to reduce communication bandwidths for SAR-based wide area search platforms to SATCOM-supportable bandwidths. The approach uses statistical representation of the background to perform aggressive compression, and wavelet-based approaches to compress detected targets to maintain signature fidelity.

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(U) The Moving Target Exploitation (MTE) program's objective is to provide significant improvements to the exploitation of ground Moving Target Indicator (MTI) radar data by providing previously unavailable capabilities to automatically detect, track, and classify high-valued ground-moving targets and maneuvering formations using all-weather airborne surveillance radar data. Four techniques are being investigated and evaluated: the automatic tracking of ground moving vehicles; the automatic analysis of moving vehicle motion patterns and behavior patterns to identify purposeful military movement; the discrimination of desired targets from other moving vehicles using high range resolution (HRR) MTI range profiling and 1-D automatic target recognition; and the imaging of specific moving targets via enhanced moving target imaging (MTIm) processing. Specific applications are targeted for MTI sensors on board the Joint Surveillance, Target, and Attack Radar System (Joint STARS), U-2, and Global Hawk platforms. In addition, system-level approaches for the application of complex-data techniques will be investigated, developed and integrated, including scatterer-specific imaging (SSI) for enhanced ATR with reduced false-alarm rates and systematic applications of coherent change-detection (CoCD).

(U) The goal of the Congressionally-mandated Geographic Synthetic Aperture Radar (GeoSAR) Program is to develop and test an airborne, radar-based foliage penetration/terrain feature mapping and geographic information system with an emphasis on both defense and civil applications.

(U) The goal of the Low-Cost Hypersonic Interceptor (LCHI) program is to cooperatively employ US and Russian expertise and low-cost approaches to develop and demonstrate a low-cost, ground-launched, hypersonic interceptor airframe.

(U) The goal of the Airborne Video Surveillance (AVS) program is to build and evaluate Airborne Video Surveillance technology to increase the tactical usefulness of video (visible and infrared) data from Unmanned Air Vehicles (UAVs). The following semiautomatic capabilities will be developed: Precision Video Registration (PVR): the real-time geolocation (2-10 meter accuracy) of moving and stopped targets in airborne video imagery using precision geo-referenced orthomosaics as reference imagery; Activity Monitoring (AM): the reliable detection of specific events (soldier incursion, removal of vehicles from cantonment areas, etc.) of points, operations areas and lines of communication (LOC); and Multiple Target Surveillance (MTS): the simultaneous tracking of multiple ground vehicles (up to 12 targets)in the sensor platform area of regard but outside a single sensor field of view.

(U) The purpose of the Sensor to Shooter to Weapon (SSW) program is to dramatically increase the probability of kill for air to mobile and moving target missions by integrating intelligence, surveillance, and reconnaissance (ISR), shooters, and weapons with closed loop control, dynamically allocated and assigned by complex, adaptive

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planning and scheduling. Through the development and application of advanced hybrid control algorithms to the mission planning and target selection (allocation) process and to the sensor/shooter/weapon assignment process, the overall timeline from target detection to weapon impact will be dramatically compressed. Further, this effort will enable the dynamic assignment of directable weapons (e.g., cruise missiles) which will provide the capability for re-assignment of near-launch and post-launch weapons to secondary targets, improving the weapon to target kill ratio and reducing the cost and logistics pipeline for a given target set.

(U) The Counter-Underground Targets project will develop and demonstrate technologies for locating, characterizing and providing targeting and related information for neutralizing underground structures. Such structures are increasingly employed to hide manufacture and storage of offensive weapons, including chemical, biological and nuclear weapons. The project will investigate and test several technologies which show significant promise in affording a national capability against these time-urgent targets. Both remote and proximal types of technologies will be studied. For remote sensing, laser vibrometry, low frequency electromagnetics, and multi/hyperspectral imaging will be tested, and for proximal characterization, micromechanical systems, air vehicles, robotics and tags will be investigated.

(U) The goal of the Counter Moving Target (CMT) program is to develop and demonstrate the capability to perform affordable precision negation of moving ground targets, deep in enemy territory. An integrated capability of ground moving target detection, tracking, and targeting will be developed using existing and planned sensor resources to produce a common ground moving target engagement picture. A complete weapons system architecture will be developed and demonstrated which includes netted air-to-ground GMTI sensors, fighter-based weapons, and long range precision weapons. This program will leverage emerging GMTI sensor platforms and technologies to provide closed loop precision fire control to initially vector manned aircraft to isolated identified moving ground targets and to eventually provide midcourse and perhaps terminal guidance to autonomous weapons for deep targeting. The precise cueing from the netted GMTI sensors will allow for lower cost weapons by reducing the complexity of, or eliminating, the terminal guidance seekers. Additionally, collateral damage will be minimized by virtue of the very precise targeting and midcourse/terminal phase flight updates. The CMT program will begin with a thorough characterization of GMTI sensor fire control, communications, and weapons system studies to minimize weapon cost. A series of laboratory and field demonstrations will develop and evaluate an CMT architecture that includes multisensor, netted, fire control and remotely guided long range weapons. Demonstrations will occur with Air Force, Army, and Navy participation and weapons.

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(U) **Program Accomplishments and Plans**

(U) FY 1998 Accomplishments:

- The Counter CC&D Program's Foliage Penetration (FOPEN) SAR completed Critical Design Review (CDR) for test and evaluation on a manned platform, providing inputs via narrowband tactical data links to the image exploitation capabilities in a dedicated Ground Control and Display Subsystem (GCDS). The Image Exploitation techniques developed under SAIP have been extended to include unique characteristics of VHF/UHF band FOPEN radar, high spatial resolution U2 SYERS MSI sensor, and multisensor correlation to improve the reliability of detection and discrimination of tactical targets under camouflage and foliage cover. Data from the FY97 Keystone97 Counter CC&D exercises have been processed to verify FOPEN SAR's ability to reliably detect tactical targets, georegistration of SAR with MSI and XBand imagery, and show feasibility of meeting ADT/C objectives of 0.1 False Alarm per square kilometer. ($23.0M)
- The GeoSAR Program completed the development of the foliage penetration, mapping radar and integrated it on a contractor furnished aircraft. The Image Formation Processor and Geographic Information System have been baselined in preparation for user validation flight tests. ($10.0M)
- Semi-Automated IMINT Processing (SAIP) integration and field testing continued towards transition system objectives with initial operational deployment of the enhanced SAIP system. Formal military utility assessment was conducted with Army and Air Force operational users under US Atlantic Command (USACOM) sponsorship. System assessment was conducted by a team from USACOM and the National Imagery and Mapping Agency. Enhanced SAIP capabilities were provided to support the Global Hawk UAV SAR,the U-2 ASARS-2, the U-2 SYERS sensor, and the ASARS Improvement Program. ($24.5M)
- The MSTAR target recognition system was integrated, evaluated and matured into a 20 target system with the ability to handle articulated, obscured, realistic target imagery under a variety of operating conditions. The system used a large database of target and clutter imagery. Transition of the MSTAR system to SAIP and Counter CC&D ACTDs occurred. Full prototypes for interactive exploitation for two analyst missions were developed and evaluated. A rapid target insertion prototype system was built and evaluated, creating 5 target models and rapid ATR training systems as a baseline. Resource management of the target recognition search process was prototyped and evaluated. An integrated, real-time demonstration of intelligent bandwidth compression using U2 and Global Hawk (utilizing the Sensor Emulation Platform) in support of potential SAIP or MSTAR exploitation was conducted. ($16.6M)
- The MTE program demonstrated near-real-time operational MTE performance against high-value moving targets by integrating the classification component and simulation testbeds developed in FY 1997 into a single MTE system testbed. This testbed was exercised with recorded Joint STARS data. In parallel, more extensive

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MPA/BPA tools have been developed, and exercised and evaluated in a ground station simulation testbed. A ground station simulation testbed has emulated the MTE data that will be available from the U2-AIP and Global Hawk platforms. The moving target classification (HRR, MTIm, 1-D and 2-D ATR) techniques were evaluated and demonstrated for U2-AIP and Global Hawk sensor parameters. Two advanced techniques, scatterer-specific imaging (SSI) and coherent change detection (CoCD) have been adapted to operate with the X-band class of radar sensors. Performance analyses for the robustness of the coherence-based techniques with X-band sensors were completed. ($15.7M)

- A joint U.S. and Russian team evaluated Low-Cost Hypersonic Interceptor (LCHI) alternatives. ($.2M)

(U) FY 1999 Program:

- The Counter CC&D Program will complete integration of a FOPEN SAR Manned Airborne Demonstrator with a tactical data link and a Ground Control and Display System to verify Global Hawk HAE UAV performance requirements. A laboratory demonstration of the Multisensor Exploitation Testbed will be conducted in preparation for FY 2000 development tests of FOPEN and SYERS MSI Exploitation and Counter CC&D Tests. Advanced FOPEN and MSI ATD/C algorithms will be extended to provide increased georegistration accuracy and potential for reduction of false alarm density through sensor fusion. ($25.0M)
- The SAIP Operational Assessment will be completed and the final transition configuration of system stood up. Demonstration of all software upgrades will be conducted. Interim operational capabilities will be transitioned for integration into the US Air Force flight test facility and to the Army ETRAC system. ($9.5M)
- The evaluation of the MSTAR 20 target/full extended operating condition (EOC) system will be expanded using new data collections, including Global Hawk data (acquired through the Sensor Emulation Platform (SEP). Scalability of the system will be demonstrated by extension to a 25 target system. Technology will be integrated with SAIP and STARLOS technology, transition to a real time demonstration system will begin. Also, a three-year effort to develop a MSTAR model-driven ATR system will begin to accommodate moving targets using MTE technology. Multiple modes of radar processing (High Range Resolution, Inverse SAR, phase history) shall be utilized to improve performance on moving and stationary targets. Development and evaluation of rapid target insertion and interactive exploitation systems will continue, with key milestones occurring in FY 2000. ($22.5M)
- The MTE Program will demonstrate MTE on-board the JSTARs T3 Testbed against a complex set (greater than 500 ground vehicles) of military vehicles. The SEP testbed will be completed and GMTI, HRR GMTI, and MTE data will be collected; a parametric assessment of HRR GMTI, vehicle length measurement, and moving target 1-D ATR performance will be completed. A multiplatform automated GMTI tracker will be developed and evaluated

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against synthetic data; a collaborative joint JSTARs, SEP, and other testbed data collection will take place against a complex set of military ground targets. This data will provide the basis for evaluating multiple platform automated GMTI tracking, automated platform cross-cueing, and advanced complex data exploitation techniques. An CONOPS and technology trade study will be conducted to develop and evaluate the application of collaborative MTE processing to support precision moving ground target engagement. The first build of the MTE-CGS ground station will be completed and demonstrated using data recorded by the SEP platform. ($15.7M)

(U) FY 2000 Program:

- Operational support to the Army and Air Force SAIP residual operational capability will be provided through the second quarter of FY 2000. ($4.6M)
- The MSTAR system will become the All-STAR system (ALL-situation Taskable ATR for Radar), capable of dealing with both moving and stationary targets using a common reasoning system. The system will be able to reason about 30 different target types, where the targets can be operating under varying conditions, including motion, background, articulation, obscuration, configuration, and target manufacturing variations. Incorporating technology from the SAIP program to analyze force structure and make use of context, false alarm rates on newly collected clutter data representative of operational challenges will drop to one per 200 square kilometers. Using distributed parallel computing, a near real time system will demonstrate recognition capabilities of stationary targets. A toolkit of interactive exploitation tools integrated with commercial technology will provide useful ATR capabilities to image analysts. The rapid target model insertion project will demonstrate the ability to incorporate a new target model into the MSTAR system within two weeks, representing a five-fold improvement over 1997 baseline rates. ($13.7M)
- The AVS program will integrate, demonstrate and evaluate airborne and laboratory systems in a simulated military mission with these technology goals: Activity Monitoring - upgrade to monitor activities (e.g. soldier movement, tactical and strategic vehicle movement) in larger areas and along extended lines of communication; Moving Target Surveillance - demonstrate increased reliability of 3 target tracking/reacquisition and scaled development to track 6 targets; Precision Video Registration - Demonstrate 2 meter RMS error geolocation accuracy on 80% of mission imagery similar to reference imagery (Class 1: less than 40 degree line of sight variation, good contrast, small seasonal variations), demonstrate similar accuracy on 75% of imagery exceeding this envelope (Class 2). ($10.5M)
- The Sensor to Shooter to Weapon (SSW) program will initiate development of hybrid control algorithms, and demonstrate a "Shooter's Control Panel" that integrates, delivers, and displays live ISR feeds. ($4.5M)
- The Counter CC&D Program will complete verification of FOPEN SAR imaging and target detection on the Army

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RC-12 Airborne Demonstrator. Real time surveillance will be demonstrated via a tactical data link and a Ground Control and Display System. A series of tactical demonstrations will be conducted with Army and Air Force exercises to validate the operational utility of the FOPEN SAR. The multisensor Exploitation Testbed will be utilized to project Counter CC&D Exploitation capabilities in a CIGSS compliant architecture. ($30.0M)

- The MTE Program will modify the on board JSTARS MTE system and the MTE-CGS ground station to produce a common MTE operating picture. A collaborative JSTARS and SEP real-time field demonstration, including multiplatform automated GMTI tracking, automated platform cross-cueing and multipath target evidence accrual will take place using data collected on a large (>500) set of military ground vehicles. ($3.0M)
- The Counter Underground Target program will employ a systems approach to investigate and model the phenomenology of underground structures. The program will define a system architecture, develop a multi-sensor concept, develop and test experimental solutions, and downselect to the most promising technologies. ($8.0M)
- The Counter Moving Target (CMT) Program will develop and evaluate a CONOPS supported by a detailed architecture for affordable precision ground target engagement. Existing sensor assets will be modified to conduct fire-control accuracy experiments against representative threats in single sensor and multisensor scenarios. Agile, active ESA technology will be exploited to characterize performance over a range of update rates, geometries, and maneuvers. Analyses will be conducted to identify weapon cueing and terminal guidance requirements for ground moving targets . A weapon system study will occur to derive weapon complexity and potential cost savings. Candidate weapons from each Service will be evaluated. An information theoretic, netted fire control architecture for precision moving ground target engagement will be investigated. System level simulations will provide performance predictions to support CONOPS and architecture development and a laboratory based demonstration of the CMT concept will be conducted. Initial joint demonstration plans will be derived. ($7.3M)

(U) FY 2001 Program:

- The All-STAR system will deal with a hundred target types, using targets generated with the efficiencies afforded by the Rapid Target Model Insertion developments. The emphasis will be on maintaining an ability to treat targets under realistic conditions, and to be able to incorporate algorithmic methods that permit the tasking of collection assets to maximally improve recognition capabilities (Active ATR). For moving targets, the recognition capabilities developed in the ALL-Star project will be integrated with tracking capabilities developed elsewhere to improve recognition rates based on multiple views. Recognition capabilities will be able to fuse radar information from targets while they are moving as well as

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information acquired when they are stationary. To image moving targets, inverse SAR methods (ISAR) will be investigated to integrate with other information to improve recognition and decrease false alarms. ($12.0M)

- The CGVT program will develop and demonstrate component technologies necessary for the demonstration of continuous tracking of moving and stationary vehicles. Automatic target verification techniques will be developed for use with high and low resolution synthetic aperture radar images of stationary targets and high-range resolution profiles of moving targets. Ground vehicle tracking systems will be extended to embrace multiple platform sensory inputs and zero-velocity targets. ($16.9M)
- The AVS program will integrate, demonstrate and evaluate airborne systems in simulated military missions with these technology goals: Activity Monitoring - increased reliability and coverage for point, area and LOC monitoring; Moving Target Surveillance: Demonstrate tracking/reacquisition of 12 targets; Demonstrate 2 meter RMS error geolocation accuracy on 90% of Class 1 and 80% of Class 2 imagery. ($8.0M)
- The Sensor to Shooter to Weapon (SSW) program will incorporate integrated control information into the "Shooter's Control Panel", including hybrid control theory for planning and scheduling. Incorporate applicable outputs from the Dynamic Data Base (DDB), Agile Information Control Environment (AICE), Moving Target Exploitation (MTE), and Advanced ISR Management (AIM) programs. ($8.0M)
- The Counter CC&D Program will complete development of concepts of operation, and hold Readiness Review and Test and Evaluation review for Demonstration #3, FOPEN image interpretation with ÂSET at 60 sq km per minute at 40 km range, and demonstrate operational detection of user-specified threats at .01 FA per sq km. ($16.3M)
- The Counter Underground Target program will prototype the systems selected in FY 2000, demonstrate the key technologies and perform proof of principle experiments to support potential future advanced technology demonstrations. ($15.0M)
- The Counter Moving Target (CMT) Program will continue the development of an affordable ground moving target engagement architecture. The weapon system study and fire control accuracy experiments will be completed. The required weapon, data link, and GMTI sensor modifications will begin. Analyses and simulations will continue to demonstrate CMT concept for deep targeting. An initial demonstration of CMT using manned aircraft will be conducted. Joint demonstration plans will be finalized to support integrated demonstration in FY 2002. ($15.0M)

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(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	90.0	72.7	53.3	52.3
Appropriated	89.7	N/A	N/A	N/A
Current Budget	90.0	72.7	81.7	91.3

(U) **Change Summary Explanation**:

FY 1998 Increase reflects reprioritization of funds within program element.
FY 2000 Increase reflects reprioritization of funds within programs.
FY 2001 Increase reflects reprioritization of funds within programs.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Plan	Milestones
May 98	Laboratory Demo of FOPEN and MSI Image Exploitation on CIGSS Architecture processors.
Jun 98	LCHI procurement and joint US/Russian team finalized.
Jul 98	Airborne data collection using SEP to support development of MTE components.
Jul 98	GeoSAR Radar, Ground Processing Development Test and Performance Baseline.
Aug 98	Airborne demonstration of ATR-based compression using SEP.
Aug 98	Demonstrate advanced MTE MPA/BPA algorithms and target classification components in ground-station simulation testbed environment.
Sep 98	MSTAR ATR demo: 20 targets, large range of EOCs; interoperability of system with portions of SAIP.
Oct 98	GeoSAR Aircraft Modifications complete for radar installation.
Nov 98	Start Integration of FOPEN Airborne Demonstration Radar.
Feb 99	Large scale GMTI data collection with JSTARS and SEP including hundreds of ground vehicles and variable radar modes.
Apr 99	Airborne MTE demonstration with Joint STARS.
Jul 99	Complete integration of SAIP transition configuration.

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Jul 99	GeoSAR foliage penetration interferometric mapping validated.
Aug 99	Demonstrate MPA/BPA and multi sensor classification techniques in a MTE ground-station testbed with real-time data from Joint STARS and SEP.
Sep 99	Flight demonstration of FOPEN radar on manned platform.
Nov 99	GeoSAR Transition to user completed.
Nov 99	Final MSTAR ATR demo: 25 targets, full range of EOC's, integration with interactive exploitation tools, SEP data.
Dec 99	Counter Moving Target weapon system study initiation
May 00	Airborne Demonstration of multiplatform GMTE tracker.
May 00	Verification of FOPEN SAR Automatic Target Detection and Cueing
Jun 00	Airborne demonstration of Airborne Video surveillance technologies
Jul 00	Participate in Army Warfighting Experiment
Jul 00	Counter Moving Target airborne fire control accuracy experiment
Jul 00	Airborne CMT fire control accuracy experiment
Aug 00	Real-time multiplatform MTE field demonstration.
Aug 00	Laboratory demonstration of CMT for first and second echelon targets.
Nov 00	ALL-Star technology demonstration, recognition of 30 target types, moving targets and stationary targets, full range of EOC's with target variability analysis, integrated with Interactive Image Exploitation tools.
Dec 00	Counter Moving Target Joint CMT demonstration finalized
Dec 00	Joint CMT demonstration finalized
Jun 01	Laboratory demonstration of CMT precision ground moving target engagement for deep targeting.
Jul 01	Preliminary design review for CMT mods
Jul 01	Counter Moving Target preliminary design review for CMT mods
Sep 01	SSW Shooter's Control Panel feasibility demonstration
Sep 01	CMT engagement demonstration with manned aircraft.
Nov 01	ALL-Star demonstration of recognition of a hundred target types, integrated with continuous tracking, using SEP data. Rapid target insertion techniques also demonstrated.
Aug 02	SSW control theory algorithm integration demonstration.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Marine Technology, PE 0603763E, R-1 #53						
COST *(In Thousands)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Ship-Sensor Systems MRN-02	19,626	24,788	36,998	43,464	48,396	58,696	60,696	63,696	Continuing	Continuing

(U) **Mission Description:** The Marine Technology Program is budgeted in the Advanced Technology Budget Activity because its objective is to identify, develop, and rapidly mature critical advanced technologies and system concepts for maritime applications that support the following goals: 1) enhancement of the ability of US naval forces to dominate the maritime battlespace, particularly in the littoral arena; 2) improved power projection capabilities of US naval forces, particularly with respect to their ability to influence the land battle; and 3) ability to counter the threat to US personnel and platforms created by the worldwide spread of increasingly sophisticated naval technology. In particular, the growing threat of quiet diesel/electric (DE) submarines, the continuing worldwide proliferation of advanced submarine and weapons capabilities, and the easy availability of modern underwater mines all represent unique warfighting challenges encountered in the maritime arena. These threats pose the greatest challenges for operations in the restricted water, near-shore regimes that are increasingly emphasized by US strategic considerations, and necessitate the continued development of increasingly affordable far-term solutions for enhancing the operating capability and survivability margins of US naval forces in the littoral.

(U) The Advanced Ship-Sensor Systems project provides innovative sensing technologies that allow US naval forces to maintain and improve their effectiveness in operating forward from the sea in the ever more dangerous conditions of future tactical environments. This project has three principal thrusts: 1) generation of improved maritime battlespace awareness through the development of advanced sensors capable of more completely and robustly interrogating the surrounding environment; 2) development of advanced communications capabilities to enable expanded maritime information networking; and 3) exploration of platform stealth approaches for increased survivability in light of these and other advanced sensor and communications capabilities, with particular emphasis on integrated sensor/stealth solutions.

(U) The Undersea Littoral Water (ULW) program is developing an active acoustic system to significantly enhance the detection, classification, and targeting performance against low-observable submarines and mines in littoral areas by application of novel acoustic activation, signal processing, and targeting techniques for air, surface, or subsurface targeting. This program of acoustic activation combined with structure based target classification is being

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seamlessly coupled to a synergistic weapons targeting approach to provide an integrated underwater cooperative engagement capability that will greatly improve overall acquisition and targeting performance against quiet threats in littoral environments. The classification/receiver activities in the ULW program, particularly the innovative use of synthetic aperture processing techniques, have major applicability to mine detection, classification, and identification as well.

(U) The Water Hammer program is conducting concept development for a standoff mine neutralization system consisting of a phased array of shock tubes to generate, focus, and transport to militarily important distances (tens of meters) a pressure pulse of sufficient energy to neutralize the threat (>1000 psi-msec; >2000 psi). Water Hammer has the potential for rapid, precision, in-stride lane clearance in deep or shallow water, reducing the need for high fidelity detection and classification. While the initial program focuses on mine/obstacle clearance, Water Hammer also has general utility as a close-in defense system for ships against multiple classes of subsurface threats.

(U) The Buoyant Cable Array Antenna (BCAA) program is investigating a full duplex link (transmit and receive) for data transfer and communications to/from submarines while operating at speed and depth. Technologies that may be employed to achieve high data transfer rates from a submerged condition include photonic signal and power links, enhanced antenna loading materials, adaptive array calibration, and enhanced communications protocols.

(U) The Autonomous In-Situation Chem-Bio-Warfare (CBW) Monitoring System's objective is to provide a covert in-situation monitoring capability of chem-bio production sites for approximately 1-2 week duration. The program will leverage off of existing MALD, UGS and sensor technology programs and program offices to integrate innovative low cost technologies to provide accurate and covert CBW agent measurements.

(U) **Program Accomplishments and Plans**:

(U) FY 1998 Accomplishments:

- Continued development, planning, and testing of the proof-of-concept Anti-Submarine Warfare (ASW) Netted Search, Acquisition and Targeting (NetSAT) system at sea, incorporating a wide frequency band, autonomous, long duration, leave behind acoustic source; signal processing for enhanced detection and attack performance (Distant Thunder); and acoustic space-time adaptive processing. ($11.4M)
- Conducted development of a multi-frequency Interferometric Synthetic Aperture Sonar (IFSAS) for mine classification. ($1.3M)

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- Within the context of Congressionally directed efforts in Smart ASW and Sonar Space-Time Adaptive Processing (STAP): conducted development of smart ASW sensors to support Netted Search, Acquisition and Targeting (NetSAT); investigated feasibility of Robust Passive Sonar (RPS) using space-time processing (STP) techniques; and conducted sonar STP and shipping noise characterization. ($3.8M)
- Commenced concept development of non-explosive underwater energy projection technology for mine neutralization (Water Hammer), including fabrication and test of initial source array test article. ($1.9M)
- Conducted initial technology assessments and feasibility testing of advanced submarine communication system concepts, including: signal exploitation, antenna array communications, and adaptive waveform generation. ($1.2M)

(U) FY 1999 Program:

- Upgrade and demonstrate detection-to-attack performance of a prototype ASW NetSAT system, incorporating: full wide frequency band, autonomous, acoustic source; acoustic space-time adaptive processing; integrated weapons control with countermeasures deconfliction; and integrated weapon/sensor signal processing approaches for enhanced attack performance. ($10.0M)
- Complete concept underwater energy projection technology (Water Hammer), including fabrication and test of second source array test article. ($3.9M)
- Autonomous In-Situation Chem-Bio-Warfare Monitoring System: Conduct source selection for subsystems and establish operational concept and system requirements. Determine preliminary design after conducting performance and cost trades. ($3.0M)
- Bouyant Cable Array Antenna (BCAA): Continue technology development of array elements and signal processing; perform phenomenology testing; conduct global positioning system (GPS) and communications link risk reduction experiments. ($1.9M)
- Commence development of Robust Passive Sonar (RPS) processing utilizing geographically referenced processing and space-time processing (STP) techniques. Begin assessment of limits of passive sonar performance. ($5.0M)
- Complete final testing of multi-frequency Interferometric Synthetic Aperture Sonar (IFSAS) for mine classification; assess processing approaches for application of synthetic aperture sonar (SAS) to short sonar arrays. ($1.0M)

(U) FY 2000 Program:

- Complete development of prototype ASW NetSAT system; conduct final operational proof of concept demonstration and coordinate transition of result to Navy. ($4.0M)

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- Autonomous In-Situation Chem-Bio-Warfare Monitoring System: Continue integration design efforts and determine final system configuration. Fabricate, assemble and conduct subsystem testing. ($9.0M)
- Water Hammer: Design, fabricate, and demonstrate an array prototype at sea. This prototype will consist of a subarray of energetically meaningful number of elements, each operating at full design specifications. The prototype will be used to verify theoretical predictions, and to identify and address design issues in the Water Hammer Concept. ($7.5M)
- Bouyant Cable Array Antenna (BCAA): Continue component technology development and risk reduction experiments; initiate design and development of a full duplex (transmit/receive) submarine BCAA prototype. ($7.5M)
- Continue development of Robust Passive Sonar (RPS) geographically-referenced processing; performance test on large fixed array. ($6.2M)
- Initiate development of synthetic aperture sonar (SAS) processing package for short sonar arrays; conduct initial performance test sequence. ($2.8M)

(U) FY 2001 Program:

- Autonomous In-Situation Chem-Bio-Warfare Monitoring System: Conduct system quality testing, initiate flight test planning for demonstration. ($14.0M)
- Water Hammer: Design, fabricate, and demonstrate at sea an operational prototype. This prototype will consist of the full complement of elements in an operational array, and will verify basic Water Hammer operational capabilities. This activity will also address system issues such as platform, propulsion, sensors (if any), and concept of operations. ($15.0M)
- Bouyant Cable Array Antenna (BCAA): Complete design and fabricate full duplex (transmit/receive) submarine BCAA prototype; conduct algorithm and software development for spatial and temporal adaptive communications link processor; begin final system-level integration. ($7.5M)
- Complete Robust Passive Sonar performance testing; commence extensions for mobile array application; complete assessment of limits of passive sonar. ($5.1M)
- Complete development of synthetic aperture sonar (SAS) processing package for short sonar arrays; conduct final performance demonstration; transition to service for system implementation. ($1.9M)

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(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	19.6	24.8	34.0	43.5
Appropriated	21.1	N/A	N/A	N/A
Current Budget	19.6	24.8	37.0	43.5

(U) **Change Summary Explanation**:

FY 1998 Decrease reflects minor repricing and completion of the Electromagnetic Turbulence Control effort.
FY 2000 Increase reflects minor program repricing and application of synthetic aperture sonar (SAS) to short arrays.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**:

Plan	Milestones
3QFY98	Complete fabrication of 2 x 2 Water Hammer source array as initial test article.
3QFY98	Conduct initial feasibility sea test for submarine Buoyant Cable Array Antenna (BCAA) concept.
3QFY98	Conduct initial sonar space-time processing and shipping noise characterization experiment.
4QFY98	Conduct Anti-Submarine Warfare (ASW) Netted Search, Acquisition and Targeting (NetSAT) system proof of concept test.
1QFY99	Complete interferometric synthetic aperture sonar sea test.
2QFY99	Complete fabrication of 4 x 4 Water Hammer source array as second test article.
3QFY99	Array prototype Preliminary Design Review (PDR).
4QFY99	Complete demonstration of 4 x 4 Water Hammer source array.
4QFY99	Conduct initial at-sea demonstration of prototype NetSAT system.
4QFY99	Conduct CWB source selection.
4QFY99	Array prototype Critical Design Review (CDR).
1QFY00	Conduct CBW monitoring system Preliminary Design Review.
1QFY00	Operational prototype Critical Design Review (CDR).
2QFY00	Begin array prototype at-sea testing.

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3QFY00 Conduct CBW Critical Design Review.
4QFY00 Conduct final NetSAT sensor-to-shooter operational demonstration including integrated surveillance and weapon sensors in a countermeasure environment.
4QFY00 Operational prototype Preliminary Design Review (PDR).
3QFY01 Begin operational prototype at-sea testing.

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APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Land Warfare Technology, PE 0603764E, R-1 #54

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Land Warfare Technology	**80,924**	**108,490**	**93,413**	**89,700**	**101,500**	**87,000**	**87,000**	**87,000**	**Continuing**	**Continuing**
Rapid Strike Force Technology LNW-01	42,315	52,600	38,000	30,000	50,000	22,000	22,000	22,000	Continuing	Continuing
Small Unit Operations LNW-02	38,609	55,890	55,413	59,700	51,500	65,000	65,000	65,000	Continuing	Continuing

(U) **Mission Description**: This program element is budgeted in the Advanced Technology Development Budget Activity because it is developing and demonstrating the concepts and technologies that will address the mission requirements of the 21st Century land warrior. Two broad efforts are being pursued in support of this objective: Rapid Strike Force Technology and Small Unit Operations.

(U) The Rapid Strike Force Technology project is developing the technologies necessary for highly mobile, covert transportation and information gathering systems to enhance U.S. early-entry capabilities. The primary thrusts of this project are the Combat Hybrid Power Systems program that is developing and demonstrating hybrid electric power and energy management systems for cavalry/scout vehicles; the Reconnaissance, Surveillance, and Targeting (RST) Vehicle program that is designing, developing and testing components and subsystems for a future lightweight, highly maneuverable manned or unmanned vehicle; the Ground Vehicle Self-Protection program; the Tactical Mobile Robotics (TMR) program that will develop mobile robotic technologies that will enable land forces to dominate battlespace using individual, or teams, of mobile robots in complex terrain; and the Mobile Tactical Operation Center program that will provide tactical commanders with current situational awareness, communications and control.

(U) The Small Unit Operations project is developing the critical technologies that will enable dispersed units to effectively perform warfighting operations that traditionally have required massed forces. Technology development efforts will focus on a comprehensive awareness capability that provides real-time, essential information for small units and individual warfighters; wireless communication technologies to permit exchange of voice, digital and video data with other systems; geolocation technologies that provide navigation information in built-up, forested and mountainous environments; internetted tactical surveillance and targeting sensors to complement information requirements not satisfied by national, theater, and component sensor programs; and automated ultra-miniature imaging and non-imaging sensors.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Land Warfare Technology, PE 0603764E					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Rapid Strike Force Technology LNW-01	42,315	52,600	38,000	30,000	50,000	22,000	22,000	22,000	Continuing	Continuing

(U) **Mission Description**: The emerging U.S. vision of future land warfare places strong emphasis on technology supporting early entry. This project is developing technologies that enable highly-mobile, covert, transportation and information gathering systems, which are important aspects of an early-entry capability. The project consists of six primary efforts: Combat Hybrid Power Systems (CHPS); Helicopter Active Noise and Vibration Control (HANVC); Reconnaissance, Surveillance, and Targeting Vehicle (RST-V); Tactical Mobile Robotics (TMR); Ground Vehicle Self-Protection; and a Mobile Tactical Operation Center (M-TOC). The CHPS, RST-V, M-TOC and TMR programs are closely coordinated with the U.S. Army, Navy, and Marine Corps, and with DARPA's Electric Vehicle (EV-01) and Small Unit Operations (LNW-02) Programs.

(U) The Combat Hybrid Power System program will develop enabling technologies and conduct demonstrations of an integrated hybrid electric power system that provides power and energy management for all of the electric subsystems throughout the future combat vehicles. The hybrid electric power system will consist of an engine/alternator, sized for average power demand, energy storage and power averaging components which provide both continuous and pulsed power, distribution networks, subsystem controls, and power conditioning devices. Vehicles will be simulated to evaluate subsystem requirements, topologies, and military utility. Hybrid electric power is an essential enabling technology for future combat vehicles given the number of electrically powered subsystems planned for implementation. The vehicles will also have greatly reduced noise and thermal signatures; and improved mobility, survivability, lethality, and fuel economy. By eliminating rigid connections between components, interior layout can be optimized, significantly reducing volumetric constraints. These advantages will result in deployable, affordable combat vehicles that meet mission requirements.

(U) The HANVC program will design, fabricate and demonstrate an Active Rotor Control (ARC) system that should achieve 10dB radiated sound pressure noise reduction, and cancel vibration and noise from the main transmission to reduce maintenance costs and improve passenger comfort.

(U) The Reconnaissance, Surveillance, and Targeting Vehicle (RST-V) program will design, develop, test/demonstrate, and transition to the Services two hybrid electric drive, lightweight, highly maneuverable advanced technology demonstrator vehicles capable of V-22 internal transport. The vehicle will incorporate technological advancements in

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the areas of integrated survivability techniques and advanced suspension. The vehicle will also host integrated precision geolocation, communication and RST sensor subsystems. Vehicle design efforts will take into consideration, to the extent possible, related technologies evolving from DARPA's Small Unit Operations Program. The RST-V platform will provide a mobile quick deployment and deep insertion capable, multi-sensor, battlespace awareness asset for small unit tactical reconnaissance teams, fire support coordinators, and special reconnaissance forces. Critical components and technologies include a high efficiency, reduced signature hybrid electric propulsion system with increased fuel economy; an advanced suspension to increase cross-country speed, and provide platform stabilization; an advanced integrated survivability suite; and the capability to operate in either a silent watch/silent movement or mechanical mode. The vehicle will incorporate modularized design components to allow for signature management and rapid reconfiguration for mission tailoring and multiple purpose utility. The Marine Corps will develop vehicle concepts and chassis, integrate the DARPA developed components, and conduct vehicle performance tests (PE 0603640M) through participation in scheduled Advanced Warfighting Experiments (AWEs) and Advanced Concept Technology Demonstrations (ACTDs) (e.g. Capable Warrior).

(U) The Tactical Mobile Robotics (TMR) program will develop mobile robotic technologies that will enable land forces to dominate the battlespace using teams of mobile robots in complex terrain (urban, indoor, rugged). TMR provides the potential for intelligent, cooperative platforms integrated with a large variety of payloads for missions that take place in inaccessible or highly dangerous environments, concentrating particularly on urban environments. Specific robotic technologies that will be advanced include perception, autonomous operation, and locomotion. Perception capabilities will include: (a) an on-board multi-sensor perception system capable of detecting at least 80 percent of decimeter-scale terrain hazards and at least 95 percent of meter-scale terrain hazards, both at 20 Hz, and (b) multi-source mapping algorithms capable of creating topological maps of urban structures with 90% accuracy. Autonomous operation capabilities will include: (a) coordination of the tactical behavior of a 10-robot team with 10X fewer command cycles, and (b) traversal of rugged/complex terrain using 1 command per 100 m travel. Locomotion capabilities will feature sub-meter-scale vehicles traveling at up to 1 m/s over 25 cm steps and decimeter-scale rubble.

(U) The Ground Vehicle Self-Protection (GVSP) Program will develop an Ultraviolet (UV) solar blind solid state focal plane array to significantly enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles at greatly reduced cost.

(U) The Mobile Tactical Operation Center (M-TOC) Program is developing technology to allow tactical commanders (Battle Force or Battalion) to have non line of sight communications; tasking and control of unmanned and manned

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assets; dynamic downlink from theater surveillance sensors and rapid exploitation technology; fused, theater and tactical situational understanding; and responsive, precision fires. The M-TOC will present the information to the commanders utilizing full immersion, three dimensional displays in multiple, dispersed vehicles that will allow operations while moving.

(U) **Program Accomplishments and Plans**:

(U) FY 1998 Accomplishments:

- Combat Hybrid Power Systems (CHPS). ($19.2M)
  - Integrated simulation/modeling with laboratory demonstration hardware to provide hardware-in-the-loop demonstration of virtual prototype.
  - Integrated hybrid electric power system subsystems for laboratory demonstration.
  - Developed technology and initiated fabrication of selected full-scale engine/alternator, power averaging, power conditioning, and power distribution and control components.
- Helicopter Active Noise and Vibration Control (HANVC) program. ($5.2M)
  - Fabricated and wind tunnel tested a Mach scale actively controlled rotor.
  - Tested active transmission mounts on a benchtop rig and on an S-76 helicopter rig.
  - Conducted near full scale fixed wing testing of an actively controlled rotor.
  - Conducted testing of eddy current vibration sensors.
- Reconnaissance, Surveillance, and Targeting Vehicle (RST-V). ($5.8M)
  - Designed, developed, and tested critical components for hybrid electric power system, mobility subsystems, and survivability suite.
- Tactical Mobile Robotics (TMR). ($12.1M)
  - Developed advanced concepts of operation for Tactical Mobile Robotics in urban missions.
  - Demonstrated tasking and control of multiple robotic vehicles from single workstation.
  - Initiated technology development for robot perception, autonomy, and locomotion.
  - Initiated designs of integrated system.

(U) FY 1999 Program:

- Combat Hybrid Power Systems (CHPS). ($20.0M)
  - Complete development of critical enabling technology for high risk power system components.
  - Utilize hardware-in-the-loop future combat vehicle virtual prototype to support technology development.
  - Test and evaluate hybrid electric power system in a laboratory demonstration.

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- Reconnaissance, Surveillance, and Targeting Vehicle (RST-V). ($9.0M)
  - Fabricate and demonstrate critical RST-V subsystems including: power system, propulsion, suspension, survivability, and controls.
- Tactical Mobile Robotics (TMR). ($19.6M)
  - Refine concepts of operation for Tactical Mobile Robotics in urban missions.
  - Demonstrate breadboard robot perception, autonomy, and locomotion capabilities in urban scenarios.
  - Complete and evaluate competing designs for integrated robotic system.
- Ground Vehicle Self-Protection Program. ($4.0M)
  - Initiate development of an Ultraviolet (UV) solar blind solid state focal plane array to significantly enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles at greatly reduced cost.

(U) FY 2000 Program:

- Combat Hybrid Power Systems (CHPS). ($5.0M)
  Complete test and evaluation of high risk hybrid electric power system in a laboratory demonstration. Transition program to U.S. Army.
- Ground Vehicle Self-Protection Program (GVSP). ($6.0M)
  - Demonstrate low defect epitaxial material compatible for photodetectors with high sensitivity operating in the solar-blind region of the spectrum (240-300 nm).
- Mobile Tactical Operations Center (M-TOC). ($5.0M)
  Initiate development of brass-board mobile command, control, and communication system, including Mobile Agile Antenna.
  Initiate development of command and control software systems, to be demonstrated and tested on the brass-board systems.
  Demonstrate and quantify advantages of active suspension vehicles for mobile command and control.
- Tactical Mobile Robotics (TMR). ($14.0M)
  Initiate development of an integrated robotic system consisting of a team of rucksack-portable semi-autonomous mobile robots capable of operating in urban terrain.
- Reconnaissance, Surveillance, and Targeting Vehicle (RST-V). ($8.0M)
  Technical testing of two completed ATD platforms to assess fuel efficiency, mobility, signature measurements, and C4I and RST performance.

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(U) FY 2001 Program:

- Ground Vehicle Self-Protection Program (GVSP). ($4.0M)
  Demonstrate solar-blind detector array with 128 x 128 pixels.
- Mobile Tactical Operations Center (M-TOC). ($12.5M)
  Develop Mobile Agile Antenna for dynamic downlink.
  Demonstrate brass-board mobile command, control, and communication system, with 3-D command environment system.
  Complete simulation of demonstration TOC system.
  Continue development of demonstration TOC system.
- Tactical Mobile Robotics (TMR). ($7.0M)
  Complete integrated robotic system development and testing.
  Conduct operational demonstrations with integrated system to include support of building assault and support of special reconnaissance missions.
- Reconnaissance, Surveillance, and Targeting Vehicle (RST-V). ($6.5M)
  Complete government demonstration/acceptance testing and participation in Advanced Warfighting Experiment (AWE).

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	42.3	52.6	33.0	28.0
Appropriated	32.9	N/A	N/A	N/A
Current Budget	42.3	52.6	38.0	30.0

(U) **Change Summary Explanation:**

FY 1998: Increase reflects: Repricing of the Reconnaissance, Surveillance, and Targeting Vehicle (RST-V) Program; Merging and repricing of the Tactical Mobile Robotics (TMR) Program - combination of the Covert Subterranean Probe Program (LNW-01) and the Cooperative Mobile Sensors, Tasking & Control, and Robotics efforts formerly funded under the Small Unit Operations Project (LNW-02).

FY 2000-01: Increases reflect addition to Mobile Tactical Operation Center; repricing of the TMR Program; and completion of the Combat Hybrid Power Systems Program.

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	May 1998
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(U) **Other Program Funding Summary Cost:** *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
PE 0603640M Marine Corps Advanced Technology	2.7	2.8	3.0	2.7
PE 0603005A Combat Vehicle and Automotive Advanced Technology	1.0	1.0	5.0	5.0

(U) **Schedule Profile:**

Plan	Milestones
May 98	Begin benchtop demonstration of an active transmission mount for HANVC.
Sep 98	Begin wind tunnel tests of the Mach-scale active rotor system for HANVC.
Sep 98	Conduct S-76 demonstration of an active transmission mount for HANVC.
Sep 98	Test RST-V critical components.
Sep 98	Complete perception, autonomous navigation, & locomotion technology breadboards (Tactical Mobile Robotics (TMR)).
Oct 98	Complete simulators and procedures for dual-fuel Molten Carbonate Fuel Cells (MCFC) power plant.
Nov 98	Conduct Reconnaissance, Surveillance, and Targeting Vehicle (RST-V) critical design review.
Dec 98	RST-V contractor downselection.
Dec 98	Complete integration of initial hardware into near-term combat hybrid power system integration lab (SIL), including test plan.
Jun 99	Demonstrate hardware-in-the-loop virtual prototype of combat hybrid power system (CHPS).
Jul 99	Complete first simulation of mobile distributed Tactical Operations Center (TOC).
Aug 99	Design of robotic perception, autonomous navigation, and locomotion technology brassboards (TMR).
Sep 99	System design defined for selected urban combat operation demonstration (TMR).
Oct 99	Demonstrate RST-V rolling chassis and vehicle subsystems.
Jan 00	Complete preliminary Design Review of robotic perception, autonomous navigation, and locomotion technology brassboards and begin fabrication of same (TMR).
Mar 00	Integrate and demonstrate advanced components into combat hybrid power system laboratory demonstration (CHPS).
Mar 00	Complete active suspension experiment (M-TOC).
Apr 00	Complete design for Mobile Agile Antenna.
Jun 00	Complete design for Mobile TOC, including 3-D environment.
Jul 00	Complete critical Design Review of robotic perception, autonomous navigation, and locomotion technology brassboards and system conops (TMR).

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Sep 00	Assemble subsystems and integrate into Marine Corps RST-V chassis.
Mar 01	Configure system for Service transition (CHPS).
Mar 01	Demonstrate 4-ton RST vehicle system capabilities in Advanced Warfighting Experiment (AWE).
Mar 01	Demonstrate Avalanche Photodetector (APD) array with 100 amps/watt responsity and low dark current.
Apr 01	Demonstrate dynamics downlink technology for Mobile TOC.
May 01	Demonstrate Command and Control 3-D environment for Mobile TOC.
May 01	Demonstrate brassboard systems and evaluate objective capabilities for demonstrator development (M-TOC).
Jul 01	System demonstration in urban mission scenario (TMR).

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Land Warfare Technology, PE 0603764E

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Small Unit Operations LNW-02	38,609	55,890	55,413	59,700	51,500	65,000	65,000	65,000	Continuing	Continuing

(U) **Mission Description:** The Services are pursuing new tactical concepts for employing small, easily deployed units as an early entry force to address future contingencies. Their objective is to enable these forces to quickly control a large battlespace with dispersed forces, control the operational tempo, engage enemy targets with remote fire, and operate effectively across the spectrum of conflict in severe communications environments. These dismounted forces must be self-sufficient and be capable of operating for several days and must be sufficiently lean to be quickly inserted anywhere in the world.

(U) Superb situational awareness is critical to the combat effectiveness and survivability of such forces. Each small team must constantly know where it is, where the other teams are and where the enemy and any other threat is located. The Services are developing lightweight radio communications and Global Positioning System (GPS) dependant geo-positioning systems packaged into fielded capabilities such as the Land Warrior System. In addition, advanced standoff sensor systems such as Predator, Global Hawk, and Discoverer II are being developed to monitor the enemy's movements and characterize the battlespace. These capabilities will greatly improve the combat effectiveness of small dismounted forces, but will be limited to operations in open areas under benign conditions. Current communications, navigation and sensor technology is not capable of operating in urban areas (outside or inside buildings), in jungles, forests or mountainous terrain. Communications technology is susceptible to enemy jamming or unintentional radio interference and is not covert to intelligence operations. Extant sensors and exploitation capabilities are limited to broad area surveillance of vehicles and facilities; data is not mined and distributed to forces at the lowest echelon.

(U) The objective of the Dispersed Land Systems Program is to develop critical technologies that will enable small dismounted forces to effectively fight anywhere, anytime. The technology needs are: semi-automated maneuver and strike/fire planning and re-planning that can be employed by commanders who are physically separated but need to be virtually collocated; automated fusion and mining of information sources to provide a "bubble" of awareness over each warrior and team describing the relevant situation; accurate geographic position estimation, other than GPS, which works in all environments; and radio links and ad hoc networked communications that "glue" the components together, operates in any environment, is covert and is resistant to interference. In addition, these technologies must not significantly increase the dismounted force's mass and power burden.

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(U) The Situation Awareness System (SAS) will integrate the technologies into a 1 kg module (plus 0.5 kg per day for the power source) worn by the individual warrior. The DARPA module will be interoperable with the Army Land Warrior equipment and provide much greater functionality at significantly less weight. The warrior module will provide the communications and computing power to fully interconnect the dismounted force and enable situation awareness information to be distributed, as well as support continuous planning and combat execution. The Geolocation Technology Program will develop and demonstrate precision miniature clocks, a low-power GPS receiver/processor (2 joules per fix) and a digital LORAN receiver to provide the accurate navigation and targeting needed for small unit operations.

(U) The Tactical Sensors Program will develop and demonstrate ultra-miniature imaging and non-imaging sensors, which can be delivered by munitions, rocket, or be hand-emplaced. These sensors will be highly automated and will replace manned observation posts while greatly increasing the target detection distance achieved by human observers.

(U) The Small Unit Experimental Program will investigate the critical SAS performance parameters. It will also analyze user-centered design input for developers and provide an independent assessment of the SAS design. The Experiment Program is functionally-focused to evaluate the sensor employment, validate network robustness and reliability, and conduct a scenario-focused evaluation of geolocation and navigation requirements in urban, forested, and mountainous terrain. A major purpose of the Experiment Program is to acquire and codify knowledge of dispersed land forces tactics to develop decision aids. The program will evaluate the utility of planning and decision aids for small units, and information-fusion algorithms required for effective situation awareness. Specialized tools will be developed to generate scenario-synchronized data for development and evaluation of the Situation Awareness System functions. The program will coordinate the use of testing infrastructure to conduct evaluations and assessment and will employ a combination of military and technical subject matter experts, computer modeling and simulation tools, and laboratory and field exercises, to provide independent validation of the SAS functionally.

(U) **Program Accomplishments and Plans**:

(U) FY 1998 Accomplishments:

- Conducted field experiment of geolocation integrated brassboard system for restricted environment geolocation. ($3.1M)
- Conducted demonstration of unique time difference of arrival breadboard for 3 meter indoor geolocation accuracy. ($.3M)
- Assessed advanced concepts and technologies for dispersed land forces applications. ($2.2M)

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology, PE 0603764E, Project LNW-02

- Conducted field experiments and demonstrated technologies at CINC and Warfighter exercises. ($5.0M)
- Continued development of situation awareness technologies focusing on plan execution and user interface functionality. ($1.5M)
- Continued development of tactical communications capability. ($3.5M)
- Developed and demonstrated Situation Awareness System detailed design. ($12.1M)
- Continued development of internetted remote control sensors to detect, localize and characterize targets. ($2.2M)
- Continued development of surveillance and targeting sensors systems for dispersed operations. ($8.7M)

(U) FY 1999 Program:

- Assess advanced concepts and technologies for dispersed land forces applications. ($3.2M)
- Conduct field experiments and demonstrate technologies at CINC and Warfighter exercises. ($5.6M)
- Complete developments for the situation awareness and real time tasking and control technologies. ($1.7M)
- Complete technology development for tactical communications capability. ($2.4M)
- Complete evaluation of enabling technologies associated with Situation Awareness System (SAS) design and conduct breadboard demonstration of critical communications and geolocation technologies. ($9.0M)
- Complete detailed design of SAS and begin development of Situation Awareness brassboard system. ($19.1M)
- Continue development of internetted remote control sensors to detect, localize and characterize targets. ($5.2M)
- Continue development of surveillance and targeting sensors systems for dispersed operations. ($9.7M)

(U) FY 2000 Program:

- Complete SAS detailed hardware and software design. ($15.0M)
  - Complete development of the Individual Warfighter System (IWS), Warfighter Tactical Associate (WTA)-Base, WTA Mobile, and Relays detailed hardware design.
  - Complete design of software modules for IWS, WTA-Base, WTA-Mobile, Relays, and network protocols.
- Complete Individual Warfighter/Warfighter Tactical Associate software coding. ($10.0M)
  Complete IWS, WTA-Base, WTA-Mobile, Relays, and network code development and testing.
  Complete situation awareness (planning, tasking, sensor control, navigation, alerts) application software coding and testing.
- Complete brassboard fabrication of the major SAS elements (IWS, WTA, Relays). ($3.0M)
- Complete development of sensor and weapon simulants for field tests. ($2.0M)

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- Integrate and perform in-house engineering tests on brassboard SAS. ($2.0M)
- Conduct performance assessment of Situation Awareness System (SAS) Phase 3 brassboard design. ($6.9M)
  - Verify that Individual Warfighting System (IWS), Warfighter Tactical Associate (WTA) and Relay Radio Frequency (RF) propagation in multipath, jamming and open environments meets 99% service availability objective.
  - Measure SAS network capacity, loading factors, data rates, and protocol performance.
  - Verify geolocation accuracy and navigation performance in urban and field environments.
  - Assess situation awareness display functionality and human - machine interface utility.
- Develop preliminary detailed demonstration plan for FY 2001 SAS operational demonstration. ($2.0M)
- Begin fabrication of 100 IWS, 10 WTA-Mobiles, 1 WTA-Base, 100 tactical sensors, and 50 tactical relays. ($7.0M)
- Complete development of internetted remote control sensors to detect, localize and characterize targets; complete development of surveillance and targeting sensors systems for dispersed operations. ($1.5M)
- Initiate laser acoustic sensor development, including phenomenology modeling and breadboard design and fabrication. ($6.0M)

(U) FY 2001 Program:

- Complete fabrication of 100 IWS, 10 WTA-Mobiles, 1 WTA-Base, 100 tactical sensors, and 50 tactical relays. ($16.0M)
- Integrate IWS, WTA-Mobile, WTA-Base with external legacy communications, data, and sensor equipment. ($7.8M)
- Test integrated Situation Awareness System (SAS). ($2.0M)
- Conduct performance assessment of final SAS Phase 3 design; Measure IWS, WTA and Relay Radio Frequency (RF) propagation in multipath, jamming and open environments meets 99% service availability objective. ($5.5M)
- Complete development of detailed demonstration scenarios to test and evaluate performance of the situation awareness system under operational conditions; perform set-up of SAS field demonstrations. ($2.0M)
- Develop training materials and conduct soldier training for field demo. ($1.4M)
- Demonstrate Situational Awareness System (SAS) performance and military utility using four tactical scenarios in field exercise with trained user. ($5.0M)
- Continue laser acoustic sensor system development; design, fabricate and test brassboard system. ($20.0M)

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(U) **Program Change Summary:** *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	38.6	55.9	60.4	61.7
Appropriated	47.0	N/A	N/A	N/A
Current Budget	38.6	55.9	55.4	59.7

(U) **Change Summary Explanation:**

FY 1998 Decrease reflects transfer of Tasking & Control, Cooperative Mobile Sensors, and Robotics efforts to the Tactical Mobile Robotics Program to project LNW-01.

FY 2000-01 Decreases reflect repricing of the Experiment program.

(U) **Other Program Funding Summary Cost:** N/A

(U) **Schedule Profile:**

Plan	Milestones
May 98	Complete precision clock environmental and cell life testing.
Jun 98	Demonstrate brassboard lifeline communication technology.
Jul 98	Demonstrate in-flight mini-imaging sensor.
Oct 98	Demonstrate and characterize various brassboard geolocation technologies.
May 99	Conduct Situation Awareness System (SAS) critical technology proof-of-concept demonstrations.
Jun 99	Situation Awareness System Requirements Review.
Jul 99	Demonstrate real time in-flight mini-imaging.
Jul 99	Brassboard testing and evaluation of internetted micro unattended ground sensor system.
Aug 99	Brassboard demonstration of broadband targeting sight.
Aug 99	Demonstrate integrated sensors, tasking and control brassboard.
Nov 99	Demonstrate brassboard Situation Awareness System network design.
Feb 00	Complete SAS Critical Design Review.
Mar 00	Demonstrate Miniature Infrared Camera (MIRC) Infrared (IR) camera.
May 00	Demonstrate integrated micro-Unattended Ground Sensors (UGS) system.

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May 00	Complete Situational Awareness System (SAS) software coding.
Jun 00	Complete SAS sensor and weapon simulant.
Jul 00	Complete brassboard SAS integration and test.
Nov 00	Complete micro-UGS field tests.
Mar 01	SAS components fabricated.
Mar 01	Complete detailed field demonstration plan.
Jun 01	Conduct demonstration readiness review.
Sep 01	Field demonstration completed.

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APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defensewide; BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Joint Strike Fighter Program, PE 0603800E, R-1 #56

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Joint Strike Fighter Program JA-01	23,019	0	0	0	0	0	0	0	0	N/A

(U) **Mission Description:** The Joint Strike Fighter (JSF) Program is the focal point for defining affordable next generation strike aircraft weapon systems for the USN, USMC, USAF, and allies. Program emphasis is on facilitating the evolution of fully validated and affordable joint operational requirements, and demonstrating cost leveraging technologies and concepts to lower risk prior to entering engineering and manufacturing development (E&MD) of the JSF in FY 2001. The JSF Program is a joint program with no executive Service. Since FY 1995, the Navy and Air Force have provided approximately equal shares of annual program funding. DARPA's Advanced Short Take Off Vertical Landing (ASTOVL)/Conventional Take Off and Landing (CTOL) Common Affordable Lightweight Fighter (CALF) project (previously known as ASTOVL) was integrated with the JSF program by FY 1995 legislation. DARPA contributed funding for the JSF Program in FY 1996 under this new program element. The US/UK international collaborative CALF Program conceived by DARPA was investigating a revolutionary approach for melding advanced technology, multi-service commonality, and improved business practices into the demonstration of an affordable, capable replacement for the F-16, F/A-18, and AV-8B. DARPA has brought this insight and experience to bear in integrating the structure and philosophy of the CALF program within the JSF framework. Through FY 1998, DARPA is serving as the Director for Joint Advanced Strike Technologies within the JSF program organization. This ensures that DARPA's expertise in advanced weapon system technologies, streamlined acquisition, and rapid prototyping are brought to bear in the JSF technology demonstration program. The program fully transitions to the services in FY 1999.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Continued ground demonstration of the concept demonstrator aircraft propulsion systems and technology maturation of the propulsion systems for the preferred weapon system concepts. ($22.2M)
- Conducted Prognostics and Health Management (PHM) technology maturation for the Joint Strike Fighter (JSF) alternate engine. ($.8M)

(U) FY 1999 Program: N/A

(U) FY 2000 Program: N/A

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(U) FY 2001 Program: N/A

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	23.0	0	0	0
Appropriated	23.0	N/A	N/A	N/A
Current Budget	23.0	0	0	0

(U) **Change Summary Explanation**: N/A

(U) **Other Program Funding Summary Cost**: *(In Millions)*

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001
PE 0603800F	251.6	458.1	465.3	240.5	23.6
PE 0603800N	243.3	448.9	461.4	245.0	26.3
United Kingdom	71.0	55.0	34.0	26.0	0
Multilateral (Norway, Denmark and Netherlands)	8.3	9.6	7.6	5.0	1.7
Canada	0	4.3	3.0	2.7	0.6

(U) **Related RDT&E:** PEs 0604800N & 0604800F: Milestone II for a joint follow-on engineering & manufacturing development (E&MD) program for the Joint Strike Fighter (JSF) is planned in FY 2001. The E&MD program will develop a tri-service family of aircraft from concepts proven under the JSF Program, incorporating affordable technologies transitioned from the JSF Program.

(U) **Schedule Profile**:

Plan	Milestones
Mar 98	Began testing of X-32 and X-35 aircraft engines.
Mar 01	Complete Milestone II for JSF Engineering Manufacturing Development.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)

DATE: May 1998

APPROPRIATION/BUDGET ACTIVITY
RDT&E, Defensewide
BA 6 RDT&E Management Support

R-1 ITEM NOMENCLATURE
Management Headquarters (R&D),
PE 0605898E, R-1 #120

COST (In Thousands)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Management Headquarters MH-01	35,039*	38,611	40,603	42,024	43,541	45,164	46,602	46,602	Continuing	Continuing

* It is anticipated that further below threshold reprogramming into Management Headquarters accounts will be required to meet statutory payroll and negotiated infrastructure costs.

(U) **Mission Description:** This program element is budgeted in the Management Support Budget Activity because it provides funding for the administrative support costs of the Defense Advanced Research Projects Agency. The funds provide personnel compensation for civilians as well as costs for building rent, physical and information security, travel, supplies and equipment, communications, printing and reproduction. In addition, funds are included for reimbursing the Military Services for administrative support costs associated with contracts undertaken on the Agency's behalf.

(U) **Program Accomplishments and Plans:**

(U) FY 1998 Accomplishments:

- Funding under this program element supported management and administration for the RDT&E programs assigned to DARPA. The majority of the funds were required for the pay of personnel who operate the Agency. The funding level reflects increased rental costs associated with the renegotiation of leases, and the related support and security requirements. A below threshold reprogramming (approximately $2 million) is anticipated to meet all support costs, but is not reflected in the control totals above. ($35.0M)

(U) FY 1999 Program:

- DARPA will continue to fund management and administrative support costs. The growth in Management Headquarters is due to increased salary requirements to accommodate mandated pay raises and a change in the mix between civilian and Intergovernmental Personnel Act appointments. This effort, which includes technical and academic personnel from commercial sector, has full support from the Department as evidenced by DoD legislative proposal to expand Intergovernmental Personnel Act appointments and increase funding in this program element. ($38.6M)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: May 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA 6 RDT&E Management Support	R-1 ITEM NOMENCLATURE Management Headquarters (R&D), PE 0605898E, Project MH-01

(U) FY 2000 Program:

- DARPA will continue to fund management and administrative support costs. Increased costs reflect salary requirements to accommodate mandated pay raises and continued change in the mix between civilian and Intergovernmental Personal Act appointments. ($40.6M)

(U) FY 2001 Program:

- DARPA will continue to fund management and administrative support costs. Increased costs reflect the cost of mandated pay raises. ($42.0M)

(U) **Program Change Summary**: *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001
President's Budget	35.0	38.6	42.6	43.8
Appropriated	34.8	N/A	N/A	N/A
Current Budget	35.0	38.6	40.6	42.0

(U) **Change Summary Explanation**:

FY 1998 Increase reflects initial below threshold reprogramming adjustments to meet infrastructure contract requirements. Further reprogramming will be necessary to fully fund statutory pay raises and other infrastructure costs.

FY 2000-01 Decreases reflect Agency adjustments.

(U) **Other Program Funding Summary Cost**: N/A

(U) **Schedule Profile**: N/A